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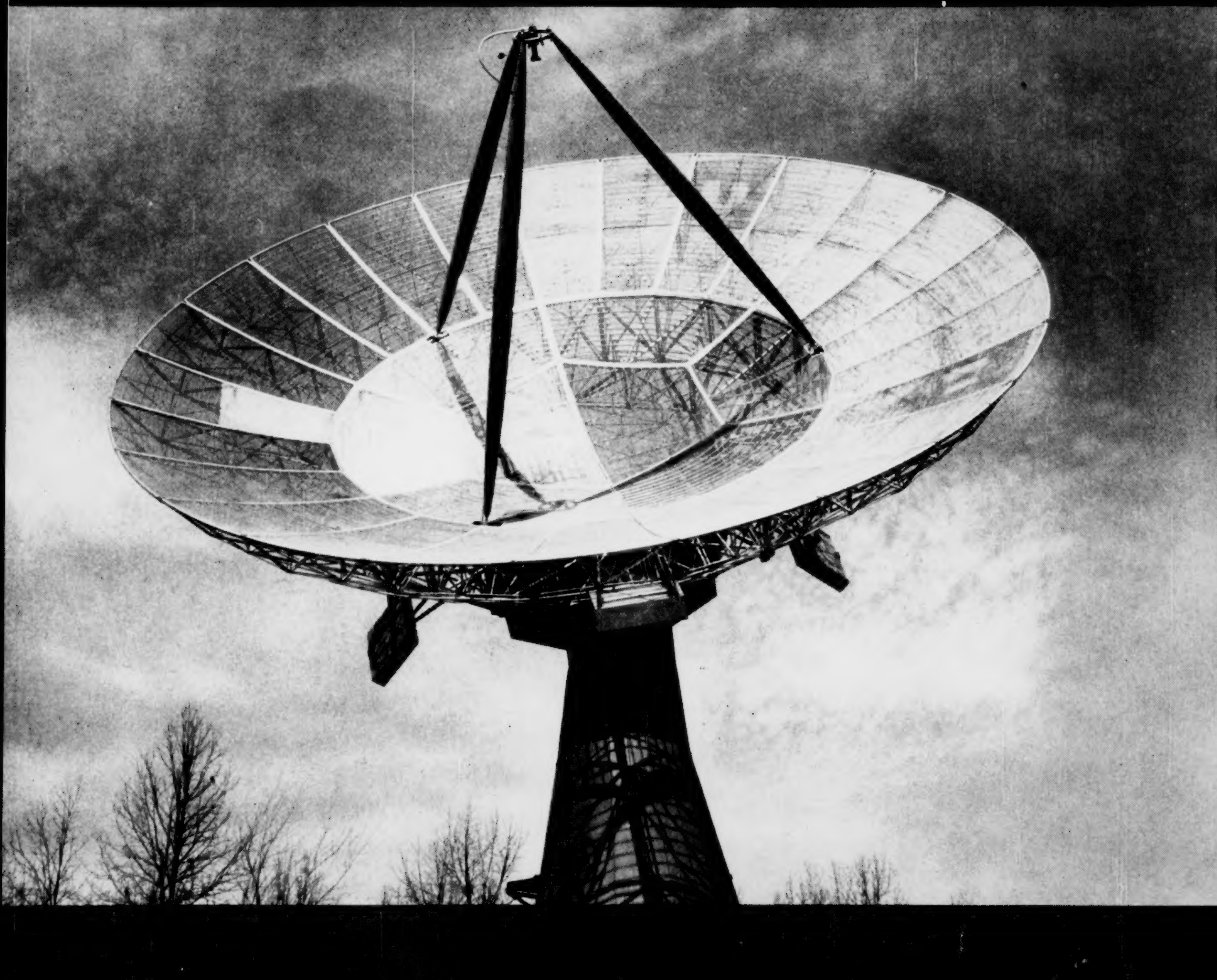

Sky and TELESCOPE

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Southern Double Stars

A REMARKABLE RECORD of long-continued single-handed effort in astronomy can be found in Volume XI of the *Publications* of the Observatory of the University of Michigan, now being added to the shelves of astronomical libraries throughout the world.

In 1928, Michigan astronomers put into operation a southern branch station, the Lamont-Hussey Observatory, at Bloemfontein, South Africa, equipped with a fine 27¼-inch refractor, for the systematic discovery and measurement of southern double stars. Seeing conditions at this location are excellent. W. J. Hussey, then director at Michigan, had long felt the need for such a survey of the badly neglected southern sky. Through the industrialist, R. P. Lamont, he obtained the funds to erect the Bloemfontein station, but Hussey died on his way to South Africa, and R. A. Rossiter took charge.

The double star work began in May, 1928. Two assistants, H. F. Donner and M. K. Jessup, participated at first, but Rossiter was the sole observer from 1933 until 1952. The results of this program, now published in full, are very striking.

A systematic search was completed over practically the entire region from one degree north of the equator to the south celestial pole. This resulted in the discovery of no fewer than 7,368 new pairs, of which 5,534 are due to Rossiter. No other observer has so many double stars to his credit. Practically all of these doubles were frequently observed, and the total number of measurements in the volume is 29,157, mostly by Rossiter.

The Lamont-Hussey catalogue is noteworthy for the large proportion of faint but very close pairs it contains. Take, for example, the star Rossiter 3340 on the first page of the catalogue. Its component stars, both magnitude 10.4, are separated by only 0.2 seconds of arc.

Could we view this system from 1/16 of its actual distance from us, the magnitudes would be 4.4, and the separation three seconds; it would closely resemble the familiar binaries Xi Ursae Majoris and Zeta Aquarii. Therefore, despite the faintness of many of the Lamont-Hussey doubles, they are quite comparable physically to objects in the lists of Wilhelm and Otto Struve.

The completion of this great project marks the virtual ending of the Bloemfontein station. "Except for six months use of the telescope on Mars during 1954 by Dr. E. C. Slipher of the Lowell Observatory, and possibly again in 1956, the Lamont-Hussey Observatory has been closed since the end of December, 1952. This date, which marked Associate Professor Rossiter's retirement, also ended the double star program and the use of the Lamont telescope on double stars."

Harvard's New Radio Telescope

David S. Heeschen
Harvard College Observatory

The workman perched on the reflector is bolting the last edge section into place, April, 1956. Photographs on this page are by Bart J. Bok.

STUDIES of the 21-cm. radio waves coming from the great hydrogen clouds of outer space have led to many exciting new discoveries, and have given astronomers valuable information about the properties of our own Milky Way system and other galaxies.

For the past few years, with a 24-foot radio telescope, Harvard Observatory has played a significant role in the development of this new field of astronomy. It was recognized very early, however, that if the full potentialities of 21-cm. research were to be realized, larger and more powerful instruments would be needed.

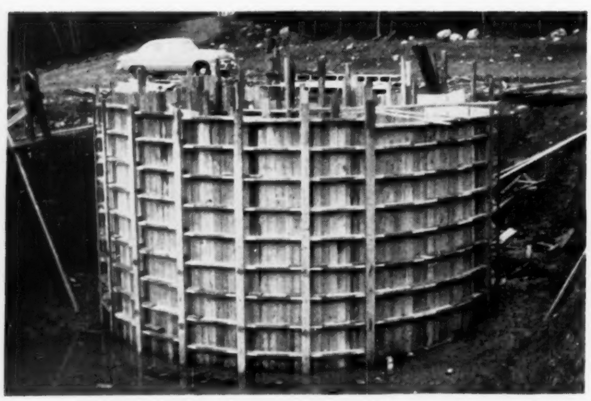
Therefore, in the spring of 1954, under the leadership of B. J. Bok and H. I. Ewen, plans were started to acquire such an instrument, and on April 28th, this year, the George R. Agassiz radio telescope was dedicated. Its name honors a long-time benefactor of Harvard Observatory. The National Science Foundation, the Research Corporation, and individual donors provided funds for the construction of this instrument.

Radio telescopes used in 21-cm. research are analogous in many respects to optical reflecting telescopes. Both have a paraboloidal reflector and a device at the focus to collect the reflected radiation and convert it to some usable form. In the optical case, the collector may be a photographic plate, or an eyepiece and an observer's eye, or any of a variety of other devices. In a radio telescope the collector, usually called the antenna feed, is a small antenna that converts the reflected radiation into electrical power that can be measured with a radio receiver.

As with optical telescopes, energy-gathering power and angular resolution depend on the dimensions of the radio reflector. The first increases as the square of the diameter, the latter linearly with diameter. Thus, a 50-foot reflector has four times the energy-gathering power and twice the resolving power of a 25-foot reflector, and is much more effective in studying weak hydrogen radiation from small clouds or other objects in interstellar space. The new 60-foot radio telescope provides a significant increase in sensitivity and resolution over existing 21-cm. instrumentation in this country. The largest receiver of this type in the world is an 83-foot dish at Dwingelo in the Netherlands.

The new Harvard instrument presents an imposing and unusual sight. At its topmost point, the reflector rises as high as a seven-story building, affording a fine view of the countryside to anyone with the energy and boldness to climb it. Much of its unusual appearance comes from the supporting pier, which is tilted to give the reflector access to the entire visible sky.

The telescope was designed and built by D. S. Kennedy and Co., Cohasset, Mass. Its 60-foot reflector is made entirely of aluminum, and weighs about 8,000 pounds. For ease of transportation and erection, it was constructed in 32 separate sections. The reflecting surface is an expanded aluminum mesh, with ⅜" square



In November, 1955, the foundation forms were completed (left). A month later snow partially covered the finished foundation. The bolts to hold the telescope extend five feet into the concrete.

openings. Because the holes in the mesh are much smaller than the 21-cm. (8.3-inch) wave length of the hydrogen radiation, the reflector presents an effectively solid surface to the radio waves. Standard surveying techniques were used by the manufacturer to check the shape of the reflector. It maintains its parabolic figure to within ¼ inch (1/64 wave length) in all reflector positions.

Supporting a reflector of this size presents a number of difficulties. It must be mounted so as to point in any direction above the horizon, and be driven to follow accurately the daily motion of a celestial object across the sky. No appreciable distortion of the figure of the reflector can be allowed. Since the telescope stands out in the open, exposed to all the whims of nature, it must be operable despite wind and precipitation, and must safely withstand extreme conditions of wind and icing. The manufacturer succeeded admirably in meeting these rather stringent requirements.

The mounting is equatorial, of a type that has some characteristics similar to yoke-mounted optical instruments. But the plane of the "yoke" is perpendicular to the telescope's polar axis, to allow the antenna to be pointed below the celestial equator without having the reflector swing down between the yoke arms. Their physical dimensions may therefore be kept within reasonable limits. A 12-ton piece of solid concrete counterbalances the reflector and its support around the polar axis. Additional concrete counterweights balance the reflector about the declination axis.

In order to keep the reflector from twisting around the declination bearings, it is connected at 14 points to a torque tube—a hollow steel cylinder 18 feet long and five feet in diameter. This holds the reflector rigid, and also serves as the declination axle.

This view shows the small feed antenna supported at the focus of the dish by three fiberglass tripod legs. The declination counterweights are clearly seen in back of the reflector. The instrument is located on a wooded ridge, 600 feet above sea level, about 25 miles west of Cambridge, Mass. Nearby are a 24-foot radio telescope, also used for 21-cm. observations, and optical instruments that include a 61-inch reflector. Photograph by Robert E. Cox.

The polar axle is probably unique among those of large astronomical instruments. It consists simply of a single roller bearing, seven feet in diameter. The outer bearing race is attached to the fixed base structure, while the inner race is fastened to the declination yoke structure. A gear cut on the inner bearing race provides the means for turning the telescope about the polar axis.

The entire 103,600-pound structure rests on a concrete foundation. Like a giant Erector-set model, its many parts are held together with nuts and bolts, some 3,000 of them. The foundation is 24 feet in diameter, four feet thick, and is securely anchored to solid rock 12 feet below ground level.

Moving parts of the telescope weigh altogether about 36 tons, and are rotated about the polar axis by a 1/10-horsepower synchronous motor, geared down from 1,800 revolutions per minute to one turn per day. Fast slewing motions of 15 degrees per minute are provided in both hour angle and declination. In addition, a continuously variable rate of rotation about either axis is available for setting purposes, and to enable the telescope to sweep back and forth across an object in the sky. The weight to be moved

The building for the electronic and control equipment is seen here, at a time when construction workers had just put the central section of the reflector in place. Photograph by Bart J. Bok.

presents no particular driving problem, since it is balanced about the axes of rotation and provides only constant inertial loads and friction.

More serious is the effect of variable winds on the large area of the reflector. To protect the gears and motors against overloads due to high winds or other causes, slip clutches are provided which relieve any stresses before they can cause damage. All motors, gear trains and other components of the drive and control system are housed in the upper part of the main telescope pier. The telescope is operated from a separate control building situated a short distance from the base of the instrument. Approximately 100 cables, comprising two miles of wire, connect the telescope and control station.

The specifications called for a pointing and driving accuracy of 10 minutes of arc. A series of tests, using both optical and radio techniques, is being made to determine the telescope's performance under various operating conditions. Preliminary tests indicate that the actual accuracy is considerably better than 10 minutes of arc, even in winds up to 30 miles per hour. While the telescope is intended primarily to operate at a wave length of 21 centimeters, the pointing and driving accuracy and the reflector's rigidity are adequate for work at 10 centimeters.

The antenna feed, a horn antenna, is held at the focus by the tripod support that is seen prominently in the photographs, including the front cover. The cigar-shaped tripod legs were made by winding fiberglass strips around a core which was later removed. This very rigid nonmetallic design keeps the diffraction effects of the support to a minimum. Energy collected at the horn is transmitted through a coaxial cable to receiving equipment mounted in a box attached to the back of the reflector.

This reflector and horn antenna give an angular resolution of 45 minutes of arc at 21 centimeters. The telescope receives and forms an average of the radiation from a portion of the sky equal to about twice the area of the full moon. Side lobes (equivalent to the diffraction rings formed by an optical telescope) pick up less than 1/100 the energy in the main reception beam of the antenna.

As important as the telescope itself is the electronic receiving equipment used with it, designed and built by the Ewen-Knight Corp. Essentially, it consists of two groups of radio receivers, each group containing 20 channels separated by frequency intervals of 100 kilocycles per second. The output of a channel in one group, representing the intensity of radiation received at some frequency, is compared with that of the corresponding channel in the second group. Such corresponding channels are separated by two megacycles. The comparison is made automatically 400 times per second, and after two minutes the average difference in outputs for each of the 20 pairs of channels is recorded. Each channel is then shifted by five kilocycles in frequency and the whole procedure is repeated. Thus, in 40 minutes a two-megacycle portion of the spectrum in the vicinity of the 21-cm. hydrogen line is observed for a particular direction in the sky.

The entire operation is automatic, including recording of the data with an electric typewriter. Each channel has a frequency band-width of five kilocycles, corresponding to a resolution in radial velocity of one kilometer per second. The receiver is so sensitive that, when used with the 60-foot antenna, it could detect a one-watt transmitter at a distance of five million miles.

The research potential of this powerful new telescope is virtually unlimited, and many fascinating problems await its immediate attention. During the coming months, investigations will be made of the hydrogen-line emission from extragalactic objects, such as the great cluster of galaxies in Coma Berenices. The intense radio sources in Cassiopeia and Cygnus will be studied in emission and absorption, to see what they can tell us about the structure of interstellar hydrogen concentrations in our own galaxy. The physical properties of hydrogen in other parts of the galaxy, such as the regions around diffuse nebulae, associations of hot stars, and the Pleiades cluster, will be correlated with optical features in those areas.

Many other worthwhile projects could be added to the list, to say nothing of the new possibilities that are invariably uncovered with improved research equipment. The field of 21-cm. research is young and rapidly expanding. Many years of fruitful and interesting work lie ahead for the George R. Agassiz radio telescope.

The dedication on April 28th was well attended by astronomers who came to the Agassiz station from near and far. This view of the instrument shows well the hollow declination axle and the 12-ton counterweight. The supporting pier is also hollow. Photograph by Robert E. Cox.

Element Formation in Stars — I

OTTO STRUVE, *Leuschner Observatory, University of California*

THREE YEARS AGO I wrote in this magazine (April, 1953):

"It seems to me that the importance of local phenomena in creating various kinds of heavy atoms in stars has not been sufficiently appreciated in the past. It is true that we have at present little, if any, information regarding the nature of these hypothetical local processes that we invoke to account for the continuous creation of lithium, technetium, and perhaps other heavy atoms. But we should remember that we are here concerned only with the production of 'traces' of elements—occasional freak atoms that may happen once in a hundred billion tries. . . .

"We should probably distinguish between nuclear processes in stars on a grand scale, such as the conversion of hydrogen into helium, and freak nuclear processes which only very rarely produce a heavy atom. The former must occur in large volumes within the stars, and must in practice be realizable under the average conditions of internal stellar temperatures and pressures. The latter need not occur at all under such average conditions. What they require is a local hot spot or other anomalous region on a star, such as a *natural* cyclotron or betatron."

When the above was written, most astronomers believed that the cosmic abundance scale of the chemical elements in the universe could only be explained in terms of a prestellar process involving something like the "ylem" of G. Gamow, R. A. Alpher, and R. C. Herman. This was thought of as an intensely hot and fantastically dense medium of neutrons, protons, and electrons, in which all the chemical elements were produced by interactions between these fundamental particles. As the medium cooled by its rapid expansion, the initial abundances remained "frozen" into the mixture. All the nebulae, dust clouds, and stars were produced from this medium, and they contained, to begin with, the same abundances of the chemical elements. All that the stars could do later to modify their composition was to destroy any small amounts of lithium, beryllium, and boron; to increase the proportion of helium at the expense of hydrogen; and perhaps to increase the ratio of the carbon isotopes, C^{13} to C^{12}, as a result of the Bethe-von Weizsäcker carbon-nitrogen cycle.

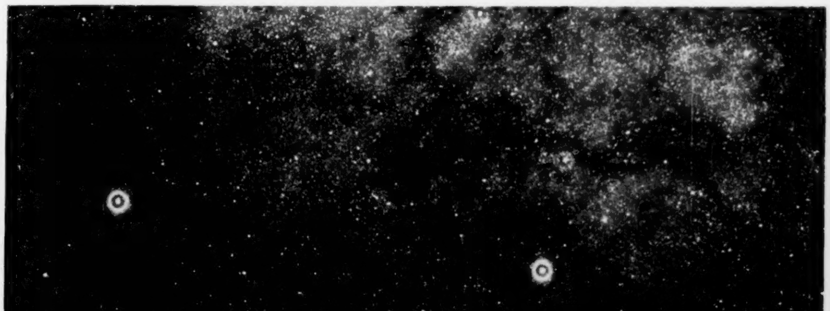
Only a few astronomers, among them G. B. van Albada and F. Hoyle, dared to think, three years ago, of the creation of heavy atoms in red giants and exploding supernovae, and even they did not regard these processes as very important in the entire picture of the formation of the chemical elements.

Today the situation is very different. In the *Proceedings* of the National Academy of Sciences (April 15, 1956), W. A. Fowler and J. L. Greenstein say:

"Can nuclear and astrophysical processes, now understood, be found which produce the heavier elements from hydrogen, in stars, under conditions such as exist at present? Is there any astrophysical evidence that element-building now occurs? We are not committed to any speculative relativistic cosmology, nor are we excluding the possibility of a primeval, explosive phase. We wish to trace the evolution of a universe containing initially only the simplest atom, hydrogen, part of which condenses into stars, leaving an interstellar gas, out of which later generations of stars may condense. We will show that known laws of nuclear physics and known astronomical processes lead to element-building in certain stars; mass loss to interstellar space, or explosion, both of which now occur, returns heavier elements, to be mixed with the interstellar hydrogen. New stars formed will have an increased proportion of heavy elements."

There can now be no doubt that the stars do serve as atomic reactors in which heavy elements are produced. But not all stars do so in the same manner or with the same efficiency. Those of the sun's type are relatively inactive, though even they "cook" the heavy elements on a small scale. The red giants and supergiants produce large nuclei copiously in their interiors, the novae and supernovae do so explosively, and the magnetic stars manufacture heavy elements near their surfaces by the betatron effect.

The meaning of the cosmic abundance scale is now very different: there is no uniform "frozen" cosmic distribution of the elements. The Milky Way is being continuously enriched in heavy atoms, and newly formed stars start on their evolutionary tracks with greater abundances of heavy elements than did the oldest stars of Population II. Individual stars are now known to differ greatly from each



Each of the myriads of stars in this photograph can be regarded as an atomic reactor, forming heavier atoms from hydrogen. Harvard's 24-inch Bruce telescope took this picture of part of the great Sagittarius starcloud, not far from the galactic center. The bright stars are Delta (left) and Gamma Sagittarii.

other in detailed chemical composition.

Until recently, there were three reasons why astronomers believed in a uniform cosmic abundance scale. First, the leakage of matter from stars into interstellar space proceeds very slowly, even though mass is being ejected by many kinds of stars: supergiants, supernovae and novae, close binaries, and very hot main-sequence stars. Consequently, stars formed even a billion years apart will differ only slightly in initial composition. Second, most of the stars whose atmospheres have been analyzed with the spectrograph happen to be neighbors of the sun in space. Thus they all belong to the relatively young Population I, and their initial compositions would not have differed greatly. Third, in such a star there is little mixing of gas between its deep interior, where nuclear reactions are forming heavy atoms, and the surface layers, the only part of the star we can analyze directly. These layers therefore still have essentially the same composition as the interstellar medium from which the star was born, and the term cosmic abundance scale is meaningful today only when we are speaking of stellar atmospheres that are free of the effects of mixing.

The new ideas on element building in stars come from the work of many astronomers. Of particular interest are the fundamental contributions of M. Schwarzschild and Hoyle on the internal temperatures of the giants and supergiants, of Fowler and Greenstein on the formation of heavy atoms in an original hydrogen star, and of Fowler, G. R. Burbidge and E. Margaret Burbidge on nuclear reactions at the surfaces of magnetic stars.

In the past few years we have come to realize that the fundamental process in stellar evolution is the gravitational contraction of a mass of gas. In its earliest stages it is an extremely tenuous interstellar cloud, containing some 1,000 hydrogen atoms per cubic centimeter at a temperature perhaps only a few hundred degrees above absolute zero. To contain enough matter to make an average star, such a cloud must originally be about one light-year or six trillion miles across.

As the cloud contracts, its internal temperature rises until nuclear processes begin to operate, the first taking place at about a million degrees. They consist of the destruction of the rather rare elements lithium, beryllium, and boron, but the star produces relatively little nuclear energy because in the original gas cloud these elements must have been extremely scarce. Their destruction results in the formation of small amounts of helium.

The star, therefore, continues to contract until its central temperature is at least five million degrees. At this stage, the thermonuclear fusion of hydrogen into helium sets in. Because of the great abundance of hydrogen, the star now releases an enormous amount of energy and its contraction is temporarily halted. During a long interval the star changes hardly at all in size and surface temperature. For cool dwarfs like the sun, this stage lasts some billions of years, but it is only a few million years for a very luminous *O*-type star, such as Zeta Puppis.

Eventually, when much of the available hydrogen supply has been converted into helium, the contraction resumes, and the central temperature rises rapidly until it reaches several hundred million degrees. In this stage the outer layers of the star are blown out; it becomes a supergiant of low surface temperature, like Antares or Betelgeuse.

As Hoyle has succinctly stated, "The nuclear transformations cannot stop a star from contracting." Its internal temperature may rise until it reaches several billion degrees! Ultimately, of course, the density of the star becomes so great—of the order of a million grams per cubic centimeter—that the star's material ceases to obey the laws of perfect gases. It becomes degenerate, and the star is then a white dwarf. But if it is more massive than the sun, it must expel some of its matter before it can settle down to its long cooling-off stage as a white dwarf. In this way, still more material is returned to the interstellar medium.

We have plenty of evidence that many stars do lose mass. This was stressed long ago by V. G. Fessenkov and A. G. Massevich, as well as by the present writer. There is some indication, but no conclusive proof, that all of the interstellar matter now in the Milky Way may have come from these gas-expelling stars; all of it may have once been inside of older stars that have already run through their evolutionary cycles. The evidence is discussed in my article on the interaction of stars and interstellar gas (November, 1954, page 11).

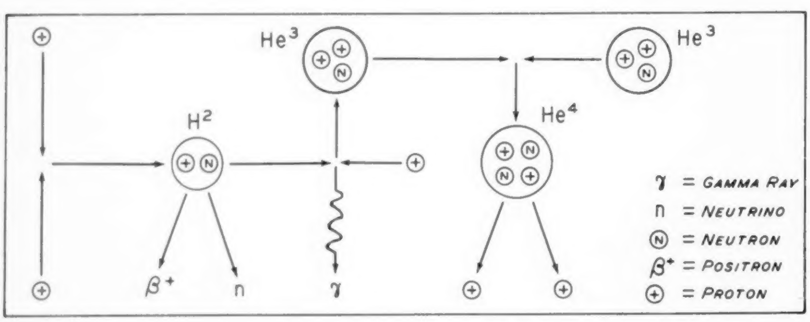
A hydrogen atom of mass 1.7×10^{-24} gram consists of one proton carrying nearly all the mass and possessing a positive electric charge of 4.8×10^{-10} electrostatic unit, and of an electron whose mass is 1/1,836 that of the proton and whose electric charge is negative, -4.8×10^{-10}. At ordinary room temperature, hydrogen atoms move with an average velocity of about two kilometers per second. At 10,000° absolute, the surface temperature of Sirius, the same atoms have velocities of about 10 kilometers per second.

Their kinetic energies at room temperature are too small to damage the atoms when they collide, but at 10,000° collisions can remove the electron from a hydrogen atom; it is then ionized, and the gas consists mainly of free protons and electrons. A collision between a proton and an electron may result in capture, reconstituting a normal hydrogen atom. Two protons cannot collide because their positive electric charges repel each other very strongly whenever the particles get close together.

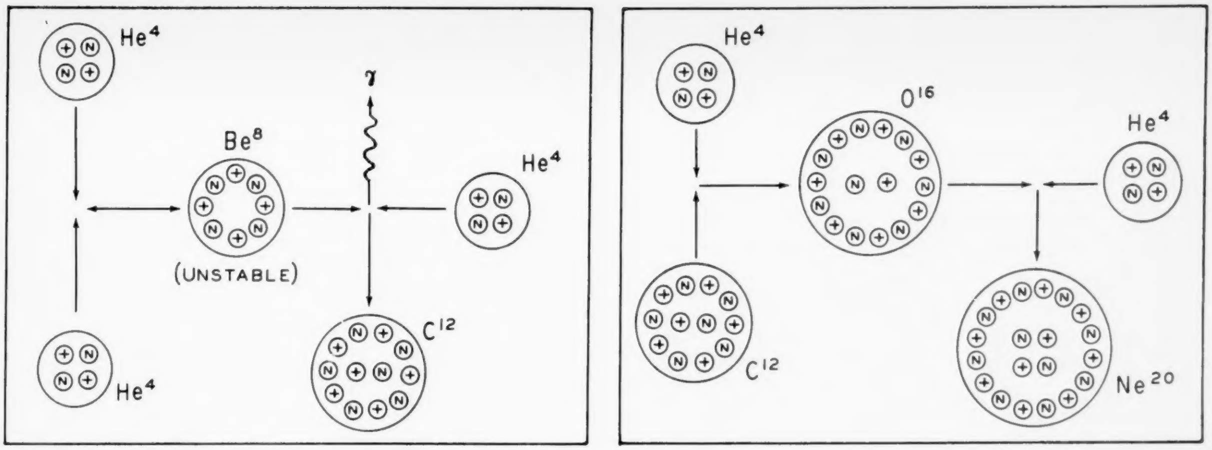
But the temperature inside a hydrogen star gradually rises because of gravitational contraction. At 20 million degrees the velocities of the protons are about 500 kilometers per second, and two protons can approach very close to each other when they meet head on. Recent computations show that they may come within 10^{-13} centimeter which is some 1/10,000 the size of a normal hydrogen atom. In such a near collision, something very remarkable happens: The two protons no longer repulse one another but stick together, bound by a very powerful though physically quite mysterious force.

Simultaneously, one of the two protons changes its character; it emits a positron (positive electron) and a neutrino, becoming an uncharged particle called a neutron. The results of the fusion is a deuteron, which has the mass of one proton plus that of one neutron (almost, but not exactly, the mass of two protons), and the positive electric charge of the proton. This deuteron, should it capture an electron, would become an atom of heavy hydrogen (H^2), also known as deuterium.

The deuteron can collide with another proton, still at the high speed of 500 kilometers per second. This proton sticks to the deuteron and does not eject a positron. But the deuteron is somewhat disturbed by the impact, and in combining with the extra proton ejects a powerful gamma ray of electromagnetic radiation. The new particle is the nucleus of a rare



In the proton-proton reaction, two protons unite to form a deuteron, with the expulsion of a positron and a neutrino. Collision of the deuteron with a proton then produces a light-weight isotope of helium, which may, in turn, form the common helium isotope. The key to the symbols is in the lower right.



The formation of carbon nuclei in hot stellar interiors is illustrated at the left; the formation of oxygen and neon at the right. Still heavier atoms may be built up in a similar manner.

isotope of the element helium (He^3), consisting of two protons and one neutron, with very nearly three times the mass of a proton.

This nucleus does not interact with either a proton or a deuteron, but if enough He^3 nuclei have been produced, two of them may collide, bringing together four protons and two neutrons. This would combine six proton masses and four positive charges, but such a particle can exist only momentarily; it quickly expels two protons, leaving only two protons and two neutrons. Thus it becomes a nucleus of the abundant helium isotope (He^4), the alpha particle. It has nearly the mass of four protons, with two positive electric charges.

The foregoing process produces deuterium and helium out of hydrogen. No other elements are generated. But as the star gradually exhausts the hydrogen in its innermost core, contraction again sets in, and when the temperature rises to about 150 million degrees a new reaction begins to function. Two alpha particles meeting with velocities of a few thousand kilometers per second fuse to form a new particle of four protons and four neutrons. This would be an isotope of beryllium (Be^8); it is not found terrestrially because it rapidly disintegrates back into two alpha particles. But in some stars there should be at a given moment a considerable number of such nuclei, even though any single one decays quickly. Fowler and Greenstein have computed that at a density of 10^4 grams per cubic centimeter, such as might exist in the heavily contracted core of a supergiant, there would be at any moment one Be^8 nucleus for every billion alpha particles.

While such a beryllium isotope lasts, it can collide with another alpha particle and produce a nucleus consisting of six protons and six neutrons. Thus it has a mass of 12 and six positive charges — it is a carbon nucleus (C^{12}). In this process a gamma ray is ejected, adding to the radiant energy of the star. Fowler points out that this reaction cannot be observed in the laboratory because it is impossible under experimental conditions to maintain a supply of the unstable beryllium isotope. But he has, nevertheless, proven the existence of the process by means of the reverse reaction, the breaking up of carbon into beryllium and helium when the carbon nucleus is excited by gamma radiation.

Once carbon has been produced, building heavier elements is relatively direct. The carbon nuclei can combine with alpha particles to produce oxygen (O^{16}), and the latter, by similar collisions, can form neon (Ne^{20}). At still higher temperatures, about five billion degrees, the nuclei of carbon, oxygen, and neon can react with each other and with their reaction products. In this manner iron (Fe^{56}) might be built up by successive steps. Fowler suggests, "The marked peak in the universal abundance curve, symmetric about Fe^{56}, is due to those stars which remained stable until all nuclear energy release had terminated."

We have thus accounted for the building up of a large number of elements in first-generation stars. But notice that carbon, oxygen, and neon came into existence only at the very high temperature of 150 million degrees, when hydrogen was practically exhausted. Therefore, no simple collisions of these heavier nuclei with protons could have played any role. Yet we know of stellar nuclear processes that involve just these atoms. Therefore, Fowler suggests that some first-generation stars explode or expel matter into interstellar space after the creation of carbon, oxygen, and neon, but before temperatures of the order of five billion degrees are reached.

The interstellar medium would thus be enriched in these elements, and new stars —of the second generation—would contain them, in addition to a large amount of the original hydrogen. At a relatively low temperature in a second-generation star's mixture, say 20 million degrees, many new processes become possible. Of fundamental importance is the Bethe-von Weizsäcker carbon-nitrogen cycle, the first detailed nuclear sequence discovered to explain energy generation in the stars (1938).

CARBON–NITROGEN CYCLE

$$C^{12} + H^1 \longrightarrow N^{13} + \gamma$$
$$N^{13} \longrightarrow C^{13} + \beta^+$$
$$C^{13} + H^1 \longrightarrow N^{14} + \gamma$$
$$N^{14} + H^1 \longrightarrow O^{15} + \gamma$$
$$O^{15} \longrightarrow N^{15} + \beta^+$$
$$N^{15} + H^1 \longrightarrow C^{12} + He^4$$

There are six steps to the carbon-nitrogen cycle, which operates at temperatures of 15 to 20 million degrees, in the interiors of stars on the main sequence of the Hertzsprung-Russell diagram.

Its starting fuel consists of four protons, and the end product is an alpha particle; the slight loss of mass appears as radiant energy. Carbon atoms, used in the beginning, reappear at the end without change in their ultimate number. Incidental new particles are N^{13}, C^{13}, N^{14}, O^{15}, and N^{15}. Many of these nuclei react with protons and with neutrons, so that ultimately in these second-generation stars all elements are generated (from hydrogen, helium, and carbon) to atomic masses as great as that of lead. But lithium, beryllium, and boron are not synthesized in stellar interiors. However, Fowler and the Burbidges suggest that they are produced at the surfaces of stars possessing spots of high and variable magnetic intensity.

(To be continued)

NEWS NOTES

By Dorrit Hoffleit

FAINT BLUE STARS

The first report on a joint survey by W. J. Luyten, University of Minnesota, and E. F. Carpenter, University of Arizona, for the detection of faint blue stars has appeared in the *Astronomical Journal*. They list 35 such stars found on blue and yellow plates taken at the Steward Observatory in Tucson. These are possibly all distant stars of Population II: their proper motions are very small.

Surprisingly, no white dwarf stars were found. The magnitude limit of the survey was about 17.3, and white dwarfs within a distance of 300 light-years should have been detected. They are so common in the solar neighborhood that three bluish stars of this type might have been expected in the 23 square degrees studied.

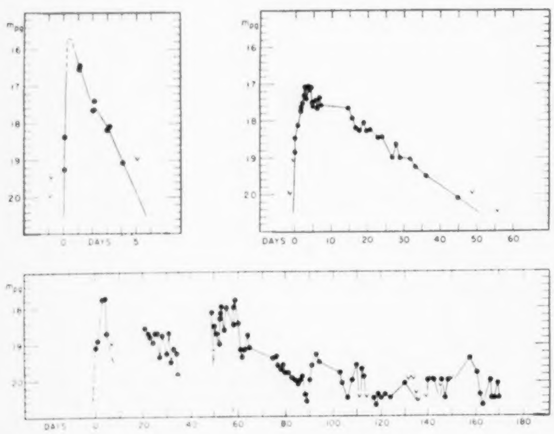
NOVAE IN M31

Our view of neighboring galaxies, such as the Andromeda nebula, M31, permits us to observe some events better than we can in our own Milky Way, where multitudes of stars and clouds of obscuring matter confuse and obstruct our view to distant parts of the system. In the Milky Way we can observe only a small fraction of the new stars or novae that occur each year. For M31, Halton C. Arp concludes from more nearly complete observations that about 26 nova outbursts take place annually, after allowing for clouded nights and other factors limiting the effectiveness of his patrol.

In 1929, E. P. Hubble made a systematic survey of the Andromeda galaxy and found 82 novae. Dr. Arp has now detected 30 more. On 290 nights between June, 1953, and January, 1955, about 1,000 photographs of M31 were taken at the 60-inch Mount Wilson Observatory reflector. The negatives show stars as faint as magnitude 20.5, except in crowded regions near the center of that galaxy, where the bright unresolved background makes discovery difficult. Apart from this region, the number of novae falls off with increasing distance from the center. The central region of the Andromeda system seems to be very transparent: the spiral arms with their heavily obscuring dust lanes do not come closer than about 2,500 parsecs from the center.

Dr. Arp compared the novae in M31 with those in our galaxy. On the basis of a distance modulus of 24.2 magnitudes, their absolute magnitudes are in exact accordance with the luminosities of well-determined galactic novae. Their light curves show the same varieties, and their outburst energies are also strictly comparable.

From his 30 light curves (published in the February number of the *Astronomical Journal*), Dr. Arp finds close relationships among the duration of a nova (defined in this case as the time during which it was brighter than apparent magnitude 20.0), its maximum brightness, rate of fading, and the energy radiated during the outburst. The two novae with the shortest durations, only five days, reached apparent magnitude 15.7, corresponding to absolute magnitude −8.5, while the longest lasted 150 days and reached absolute magnitude −6.1. The diagram is adapted from the *Astronomical Journal*.



These selections from Dr. Arp's light curves of novae in the Andromeda galaxy are: (Upper left) One of the two fastest novae on record, with an initial rise of about a magnitude per hour. (Upper right) An extended spell of favorable weather allowed the best pre-maximum and maximum observations of any of the M31 novae; note the abrupt slowing of the rise in brightness just before maximum is reached. (Bottom) One of the novae of long duration.

ORIGIN OF BINARY STARS

Fission as a mechanism for the formation of spectroscopic binaries appears to be finally ruled out, according to G. P. Kuiper, Yerkes and McDonald Observatories, in the *Publications* of the Astronomical Society of the Pacific (December, 1955).

Amplifying the arguments he set forth in 1935, Dr. Kuiper favors a single mechanism for the origin of all types of double stars, spectroscopic as well as visual. Citing recent work on the dimensions of globules, he believes that a number of condensations in a single protostar could result in a multiple star, though systems of more than two components would ordinarily not be stable unless the distances between the members permitted them to survive under their mutual gravitation.

There is no evidence for two classes of binaries, close and wide, as often supposed in the past, Dr. Kuiper confirms. The apparent division into visual and spectroscopic binaries is caused by observational selection. Fission cannot take place in bodies having as strong a density concentration toward the center as is now known to exist in stars.

Dr. Kuiper finds that his model for the formation of double stars from protostars gives predictions in reasonable accord with observation for the relative numbers of binary orbits of different sizes.

LUNAR MARIA

The origin of the moon's surface features is a long-debated problem whose eventual solution depends on careful studies of surface detail, such as are being carried out by Dinsmore Alter, of the Griffith Observatory. In the February *Publications* of the Astronomical Society of the Pacific, he presents a series of beautiful photographs of the lunar maria ("seas"), together with a key photographic map for identification. He also lists no fewer than 12 observational facts that any acceptable hypothesis concerning the origin of the maria must explain, or at least not contradict. These include the large sizes of the maria, the smoothness of their surfaces, the appearance of ghost craters within them, the darkness of the maria compared with other areas of the moon, and properties of their shores.

Detailed examination of Maria Nubium, Humorum, Nectaris, Crisium, Serenitatis, and Imbrium, suggests to Dr. Alter that lunar maria have resulted from sinkings of the surface, followed by overflow of molten rock in the sunken areas. Impacts of asteroids or large meteorites may have triggered these sinkings, but they alone cannot have produced the maria as seen now. To this, Mare Imbrium, within its central ring, may be an exception; it could have been formed more or less as it is now by an asteroid collision. Although many craters appear younger than the maria, the latter have come into existence rather late in the evolution of the lunar surface, Dr. Alter suggests.

FACING PICTURE: The southeastern portion of the waning moon, age 24.3 days, is here enlarged from a negative taken August 20, 1938, by J. H. Moore and J. F. Chappell, with the Lick Observatory 36-inch refractor. This is the sixth in a series of sectional views which began in the February issue. To the left of center is the compact dark "sea," Mare Humorum, with the large crater Gassendi at its northern (lower) edge. Farther north lies part of the huge gray expanse of Oceanus Procellarum, and in the lower right the large dark oval is the ring plain Grimaldi.

Harrisonburg Observatory Expands Facilities

AT Eastern Mennonite College, Harrisonburg, Va., the Vesper Heights Observatory has opened its new Astral Hall, with a seating capacity of 100 for its astronomy classes and for general public demonstrations of a new Copernican-type planetarium or orrery.

Designed by the observatory director, M. T. Brackbill, the hall is an air-conditioned, 25-by-40-foot brick structure. It is an addition to the original observatory dome, in which is housed the first Spitz planetarium sold in the United States.

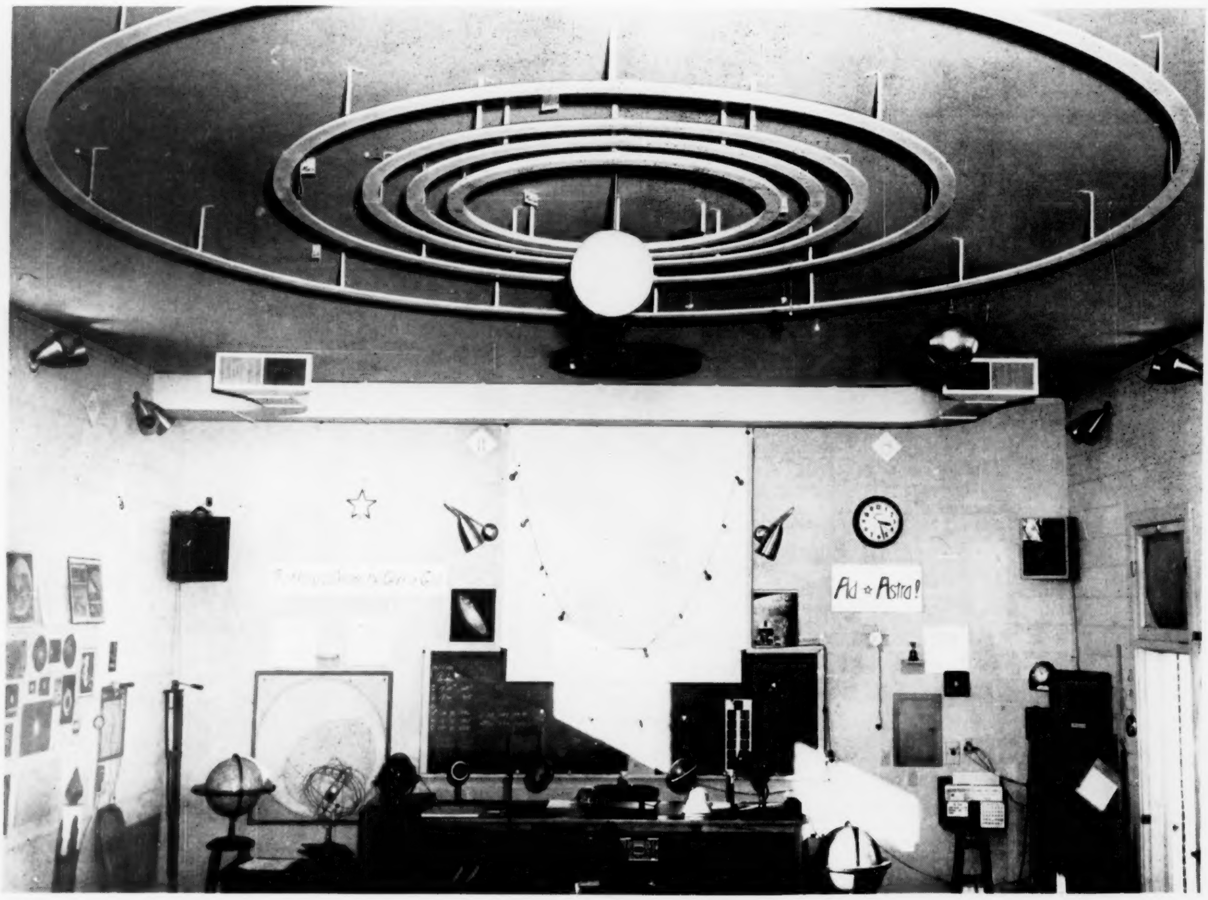
The orrery is attached to the ceiling of the lecture hall, in the same manner as those at the Hayden Planetarium in New York City and the Morehead Planetarium at Chapel Hill, N. C. The earth is represented by a lighted electric bulb, and the other planets are proportionately sized steel spheres: Mercury, Venus, Mars, Jupiter, and Saturn are included. The correct relative speeds of revolution around the central light globe (the sun) are obtained by means of tiny electric model-train locomotives that operate on circular tracks. The photograph shows how each planet (except Saturn) is suspended from one of these engines.

When the sun globe is not lighted and the bulb for the earth is turned on, the apparent retrograde motions of the planets are shown by their shadows.

Other devices and charts on the walls and ceiling facilitate the study of planets and constellations. In the ceiling above the lecture platform is an electrically illuminated planisphere, one of the many devices designed by Mr. Brackbill, who first became interested in astronomy when he saw Halley's comet in 1910. The hall is equipped with motion-picture projection facilities.

The new addition was constructed with funds donated by members and friends of the Astral Society, which recently celebrated its 25th anniversary. Composed of amateurs both in and out of college, the society has more than 900 members who studied astronomy under Mr. Brackbill. They reside in all parts of the United States and in more than a dozen foreign countries. Mr. Brackbill keeps in touch with them through society publications and correspondence.

In 1930, the Astral Society donated a 6-inch reflector to the college. The observatory now has a 12-inch reflector, seen left of center in the accompanying picture: a 6-inch refractor (covered); two

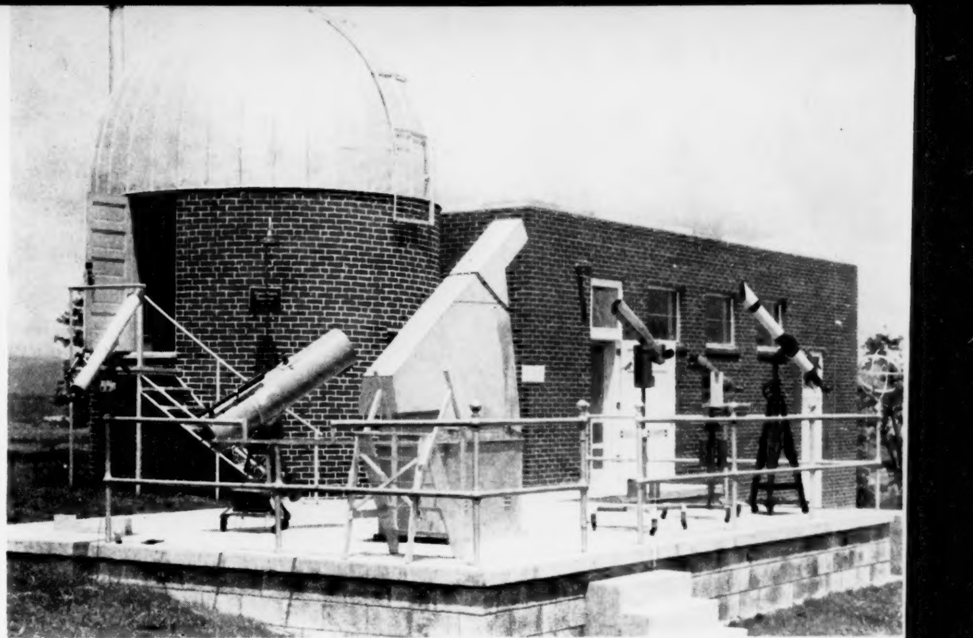


The new lecture hall serves as an exhibit room, where the lecturer has a versatile array of models, globes, charts, photographs, and demonstration devices at hand to illustrate astronomical phenomena. The model-train locomotives may be seen on some of the tracks that represent planetary orbits in the ceiling orrery.

4-inch refractors, a 4-inch German binocular, and a 5-inch Japanese binocular. Setting up these instruments on the outdoor platform has proven more practical for public and student observing than when one larger telescope was operated in the dome, where the Spitz planetarium projector is now housed.

The observatory dome was built in 1938, donated by the senior class of that year. Since then, more than 12,500 persons have visited the observatory, including school and scientific groups, religious and civic organizations, and individuals. Planetarium demonstrations are given throughout the year for both students and the public.

In all his work, Mr. Brackbill is assisted by Robert Lehman, who should be contacted by all persons and groups wishing to visit Vesper Heights Observatory.



The observing platform provides places for instruments of many sizes.

The Dusky Markings of Venus

THE PLANET Venus, which was so conspicuous in the evening sky this spring, has been scrutinized through nearly every amateur telescope. Most observers will agree that the planet is a difficult telescopic object, apart from its conspicuous phases. Its brilliant white surface does show very delicate pale gray shadings, but these are hard to make out, and every conscientious observer who records them recognizes the danger of subjective effects. How can he guard against illusion?

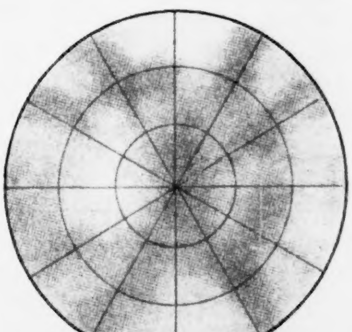
Dr. Audouin Dollfus, of the Meudon Observatory, discusses this problem in his article, "A Visual and Photographic Study of the Atmosphere of Venus," which appeared in the November, 1955, issue of the French journal *L'Astronomie*. This important paper summarizes a decade's observation of the planet. In it he has investigated the subjective detail superimposed on the real features of Venus, using telescopes ranging from 2 to 24 inches in aperture, and powers from 20x to 1,200x, through different color filters.

Three types of illusion were noted as common: elongated parasitic shadings appearing to meet at the planet's cusps; a brightening along the planet's limb; and a central spot, forming a short arc parallel to the limb. These spurious features are most marked when Venus is near quadrature, and lessen when it is near superior conjunction. They diminish with increased magnification, becoming localized near the tips of the crescent.

If the magnification is high enough so the telescopic image of Venus has six times the diameter of the moon as seen with the naked eye, then these illusions do not affect the observer appreciably, according to Dr. Dollfus. Applying this rule, the lowest power that can be safely used for studying the dusky markings on Venus is about 350x, even when the planet is nearest.

For his series of over 100 drawings of Venus, Dr. Dollfus used the 24-inch refractor of the Pic du Midi Observatory, with a magnification always at least 500x. The seeing conditions at this station in the French Pyrenees are exceptionally good for planetary work. Observations were carried out at night, by twilight, and in full daylight. When a metal screen on a long pole was used to shield the objective from direct sunlight, Venus could be successfully observed even if only three degrees from the sun.

The general conclusions are that Venus is covered with a high cloud layer, through whose gaps dark, drifting, lower-lying clouds can be seen, as well as dark surface markings (or low atmospheric phenomena stabilized by surface features). From the semipermanent nature of the surface markings, Dr. Dollfus believes that the rotation period of Venus is 224.7 days, the same as the period of orbital revolution, in agreement with earlier findings by G. Schiaparelli, J. Camus, and A. Danjon. If this is correct, the same hemisphere of Venus is always turned toward the sun. (Some other astronomers believe that the rotation period is much shorter.)



This map of the permanent markings of Venus is by Audouin Dollfus, from drawings of 1948 to 1953. The chart is centered on the subsolar point, and the map projection is such that the concentric circles are 30 degrees apart on the planet's surface. Reproduced from "L'Astronomie."

A useful method was employed in preparing a map of the surface features. To distinguish between these and the transitory lower cloud formations, all drawings made within a 10-day interval were copied on cellophane. The dark markings were represented by stipplings of fine dots, whose concentration was proportional to the contrast. The cellophane representations, all the same size, were exactly superimposed, and a photographic contact copy was made using parallel light. In this way, permanent surface features were reinforced, while temporary markings were smoothed out.

The Pic du Midi photographic observations were made in yellow, blue, and ultraviolet light. While all of these showed something of the dark markings, ultraviolet light of wave length 3400 angstroms gave by far the best results. Bright clouds and conspicuous mottlings appeared, but these features changed so rapidly that they could not be recognized from one day to the next. In addition, Dr. Dollfus' ultraviolet photographs often showed cloud bands, such as have been described by G. P. Kuiper from his pictures secured with the 82-inch McDonald Observatory reflector. (See *Sky and Telescope*, February, 1955, page 131.)

J. A.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 94th meeting of the American Astronomical Society at Columbus, Ohio, in March. Complete abstracts will appear in the Astronomical Journal.

Origin of Asteroid Groups

New light on the early history of the solar system has been provided by a study of asteroid orbits by E. Rabe, University of Cincinnati Observatory. As has long been known, few minor planets have periods that are close to simple fractions of Jupiter's period; these absences form what are known as Kirkwood's gaps in the system of the asteroids.

One such gap is for a period of 5.93 years, half that of Jupiter, but some 500 minor planets have periods near this value—most of them around 5.5 years—and comprise the Hecuba group. Dr. Rabe has studied how this pattern would have changed if the mass of Jupiter were originally greater. Tracing the asteroid motions back into the remote past, he finds that both the gap and the Hecuba group were then less marked, and when the mass of Jupiter was 20 times its present value both features were unrecognizable.

On G. P. Kuiper's theory of the origin of the planets (see page 350, June issue), Jupiter was once much more massive than it is today, and he calculated from considerations of stability and chemical composition that the protoplanet lost 19/20 of its mass. The same factor of 20 resulted from Dr. Rabe's explanation several years ago of the Trojan asteroids as escaped satellites of Jupiter.

Since an approximately uniform original distribution of the asteroids is a natural assumption, Dr. Rabe's latest work not only accounts for the origin of the asteroid families, but adds support to Dr. Kuiper's ideas on the formation of the solar system.

A Great Solar Explosion

An unusually striking flare on the edge of the sun, observed on February 10, 1956, at the Sacramento Peak Observatory in New Mexico, was described by Donald H. Menzel, Harvard Observatory.

Motion pictures of the sun's east limb, taken with the patrol coronagraph, recorded a bright bubble of gas expanding at the rate of about 60 miles per second. It increased rapidly in brilliance for 5 to 10 minutes; simultaneous spectrographic observations with the large coronagraph revealed the hydrogen-alpha line to be very broad.

As the flare reached maximum brightness, its upper portion underwent a remarkable acceleration. A knot of material about 20,000 miles in diameter speeded up from 60 to 700 miles per second within two minutes, thus attaining the greatest outward velocity probably ever recorded for any prominence. The prominence then rose at steady speed until it finally faded from view some 200,000 miles above the solar surface. Altogether, the energy of the explosion equaled that of 100 million hydrogen bombs.

Simultaneously with this flare, the signal strength of distant short-wave stations decreased markedly. This indicated an increased absorption in the earth's ionosphere, caused by the intense ultraviolet light from the flare. At the same time, strong bursts of solar radio noise were observed by the National Bureau of Standards, at Boulder, Colo.

National Radio Observatory Site Selected in West Virginia

New details of the proposal for a national radio observatory were presented at the Columbus meeting by L. V. Berkner, president of Associated Universities, Inc. Among the highlights of his talk were new information on the design of the radio telescopes and the announcement that a site has been chosen in the mountains of southeastern West Virginia.

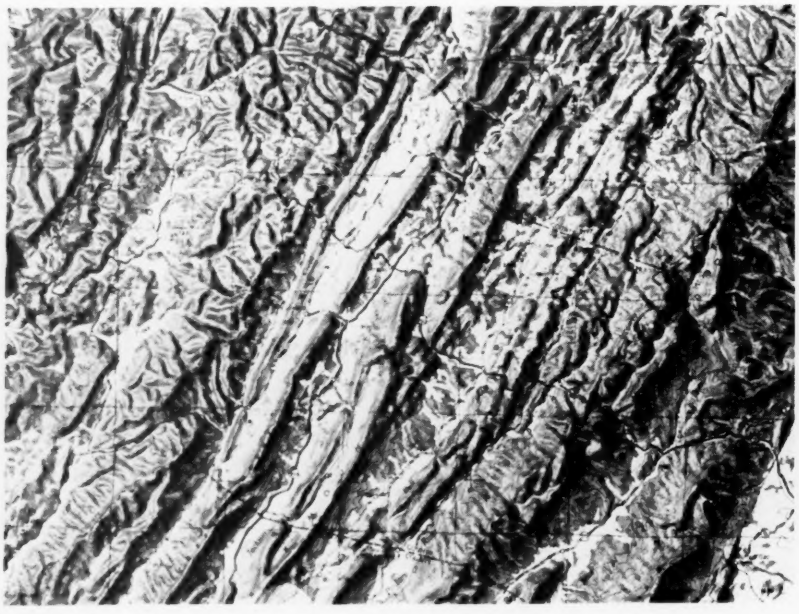
As reported on page 199 of the March, 1956, issue, the National Science Foundation is asking for funds to erect a 140-foot paraboloidal antenna, to be followed eventually by a 600-foot instrument. The plans call for making the radio observatory facilities available to all qualified astronomers.

The versatility and relative simplicity of large steerable antennas has led to the adoption of this type for the project. Such antennas have advantages in the interpretation of data, available band width, and the avoidance of the observational ambiguities inherent in other types of instrument. The radius of the reflector should be as large as possible, for resolving power and sensitivity depend on this.

Dr. Berkner pointed out that theoretically it might be possible to build a paraboloid up to 2,000 feet in diameter, a limit set by the mechanical strength of construction materials, but such a monster would be excessively costly and would be difficult to use. The best compromise between cost and optimum operating characteristics appears to be a 600-foot dish.

Building the 140-foot instrument first will give valuable experience and allow the observatory to begin its work sooner. It will operate over a much wider range of wave lengths than existing instruments, extending to as short as three centimeters. The mounting will be altazimuth, not equatorial, as the former type is less costly. Variable driving in both instrumental co-ordinates can be provided by an automatic computer. The 600-inch instrument will have to be an altazimuth.

Basic specifications for the 140-foot telescope are a focal length of 70 feet, surface tolerance $\pm\frac{1}{4}$ inch, focal point position $\pm\frac{1}{4}$ inch; full precision in winds up to 30 miles per hour, usable up to 45 miles per



This relief map includes the Green Bank-Arbovale valley about one inch from the left edge and 1½ inches from the top. In the lower right (southeastern) corner is a bit of the upper Shenandoah Valley, not far from Staunton, Va.

hour, safe to 120 miles per hour. The instrument must be able to point to the entire visible hemisphere of the sky, its antenna beam inherently rigid to 10 seconds of arc. The slewing rate will be from 5 to 30 degrees per minute of time, the setting rate one degree per minute. It must track at sidereal, planetary, or lunar rates with an accuracy of 10 seconds of arc.

In selecting the site for the observatory, by far the most important consideration was to avoid interfering radio noise over a frequency range of about 10 to 35,000 megacycles. For the lower part of this interval, the basic noise level is nearly uniform over the whole country, because of scattering in the atmosphere, but the government is acting to secure some entirely free channels on which there is no transmission.

At higher frequencies, there is serious man-made interference from electrical machinery and appliances. The only protection is found in mountain-ringed valleys in thinly inhabited localities, where few aircraft fly over, and where the telescope cannot see high-voltage power lines.

In addition, it was desired to have the station conveniently accessible from research institutions in the East and the Middle West; also, within about 300 miles of Washington, D. C. The latitude should be southerly enough to permit observation of the center of the Milky Way galaxy in Sagittarius, yet far enough north to allow studies of auroras and polar blackouts.

The village of Green Bank, W. Va., about 35 miles south of Elkins, was chosen as the most favorable of the 29 sites investigated. It is in a deep, flat 10,000-acre valley, surrounded by several ranges of 4,000-foot mountains. Here the radio noise level is probably lower than anywhere else east of the Rocky Mountains, excepting possibly some places in northern New York and Maine, but there the winters are too severe to operate large radio telescopes.

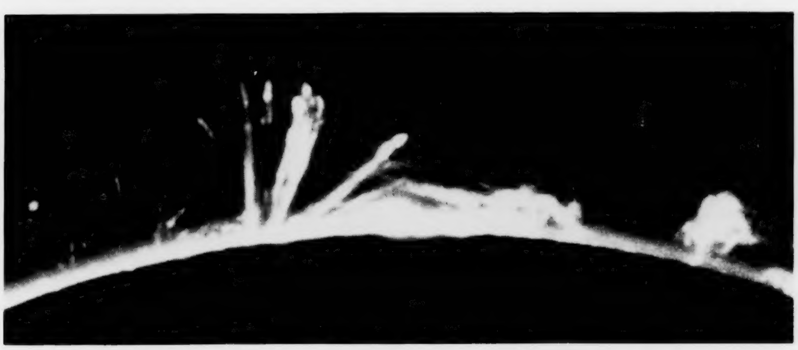
According to Dr. Berkner, options have already been secured for parcels of land in Green Bank and the adjoining village of Arbovale, and engineering studies are underway to establish the feasibility of construction on these sites. If funds for the project are granted by Congress, the plans are sufficiently advanced to allow a prompt start on the national radio astronomy observatory.

The approximate locations proposed for various instruments of the national radio observatory are shown on this aerial photograph of the Green Bank-Arbovale region. Photograph courtesy Associated Universities, Inc.

Solar Prominences and Radio Noise

At the High Altitude Observatory, J. Paul Wild and Harold Zirin have searched for correlations between solar prominence activity and radio noise from the sun. They compared motion pictures of prominences made at Sacramento Peak, N. M., and at Climax, Colo. (in the period 1949-1955) with solar noise records at 167 megacycles. Although no close connection was found, several eruptive prominences had occurred simultaneously with radio bursts.

Another problem was what type of sunspot tended to produce radio storms on passing the edge of the sun. The most effective spots, it was found, are associated with looped prominences having material streaming downward from the corona, of the type illustrated below. Of 14 spots producing enhanced radio noise, 12 were of this description. The origin of such noise, Drs. Wild and Zirin pointed out, must lie in the corona, and in the presence of strong, ordered magnetic fields. The existence of these conditions is indicated by the occurrence of looped prominences.



This region of the sun, containing looped prominences, passed the solar limb on May 2, 1950. It was associated with a large radio noise storm when it was central on the sun on April 27, 1950. This is one frame of a series of hydrogen-alpha pictures made with the Climax coronagraph. High Altitude Observatory photo.

Formation of Stars

Most astronomers now believe that the stars were formed out of the very tenuous interstellar gas clouds of our galaxy. The birth of a star thus requires the contraction of a region of gas several parsecs in diameter to about a hundred-millionth of its size, with a corresponding increase in density.

G. C. McVittie, University of Illinois Observatory, has investigated the mathematically difficult problem of how such a gas cloud collapses to form a star. He uses a method of attack, in this problem of gas dynamics with gravitation, that is based on Einstein's equations of general relativity. To simplify the problem, he considers only two forces: gas pressure, which seeks to distend the cloud, and self-gravitation, which tends to contract it.

The solution obtained is not unique. Dr. McVittie found that there are many different ways in which a sphere of gas, at first at rest but not in equilibrium, can flow internally toward its center until all the gas finally comes to rest again in a relatively small volume, forming a body of comparatively high density at high temperature having the known properties of a star.

But all the different ways have two properties in common. During the collapse of the cloud, gas flows inward with a speed that is proportional to its distance

from the center, and the flow is accompanied by the release of energy in the form of radiation. It can be proved that no shock waves occur; these might otherwise halt the shrinking of the mass of gas. The time required for the collapse into a star is about 100 thousand to 100 million years, depending on the initial density of the cloud.

For the shrinking to begin, the temperature of the gas cloud must be very low, and Dr. McVittie suggests that "cold spots" in the interstellar medium may be necessary for star formation. He emphasizes that his solution indicates only that stars *may* form in this way, and that he has omitted several very important factors, such as the opacity to the outgoing radiation and the viscosity of the gas.

New Design for a Radio Telescope of Large Aperture

Radio telescopes of the reflecting type, with paraboloidal receivers, have limited resolving power because radio waves are millions of times longer than light waves. Radio telescope apertures have to be scaled up correspondingly to match the resolution by optical telescopes—the resulting huge sizes present many obstacles, such as very high cost. Yet the reflecting type of instrument has many times the energy-gathering ability of interferometer arrays.

To meet this need for large aperture, John D. Kraus, of Ohio State University, is constructing a reflector system of new design that can eventually be built in tremendous sizes. The first component will be a flat, tiltable reflector that can scan north and south along the meridian; scanning in right ascension will be provided by the diurnal rotation of the sky. The second part will be a fixed curved reflector with a paraboloidal shape; this will be set up to the south of the first element to receive the energy it reflects. A horn at the focus of the paraboloid will funnel the radio waves into an ultrasensitive receiver housed in a small building. The surfaces of the reflectors will be covered by metal screen, and the ground between them will also be surfaced with this material, forming an integral part of the system.

The National Science Foundation has granted $48,000 to Ohio State University for the construction of the center section of the instrument, which will measure 700 feet long by 75 feet high when it is all completed. It will be erected on a site provided by Ohio Wesleyan University at Delaware, Ohio, near the Perkins Observatory. The completion of the center section, 350 feet long, is expected in about a year.

To test the new design, a scale model 12 feet across was constructed, and it is so satisfactory that it is being used for studying radio emission from the sun. Operating at a wave length near one centimeter, the model has a resolving power of about one quarter of a degree in right ascension.

Dr. Kraus estimates that a unit of the same design, 2,000 feet long by 200 feet high, would cost about a million dollars. Such an instrument would be by far the largest reflecting-type radio telescope in the world.

Ultraviolet View of the Sky

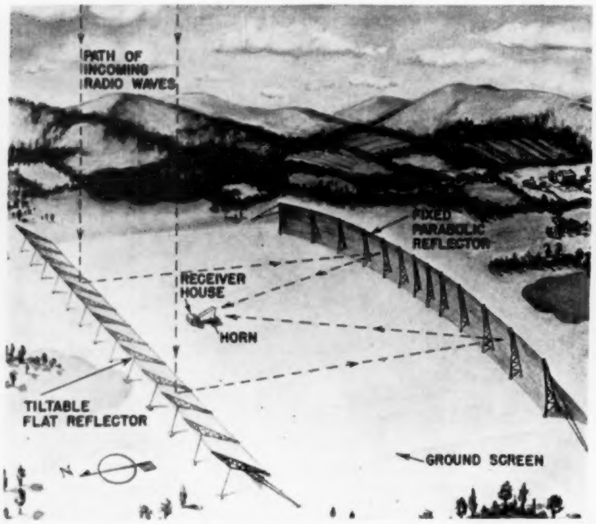
The earth's atmosphere is opaque to ultraviolet light of short wave length, so that astronomical observations at wave lengths shorter than about 2900 angstroms were not possible before rockets ascended higher than the absorbing layers of the air. Already, the ultraviolet spectrum of the sun has been photographed from high-altitude missiles, and it may soon be feasible to observe other celestial bodies from rockets or artificial satellites.

Therefore, at Harvard Observatory Robert J. Davis has made a detailed prediction of the appearance of the starry sky as it would be seen in ultraviolet light at 1249 angstroms, near but not coincident with the Lyman-alpha spectrum line of hydrogen. For his extensive calculations of the ultraviolet brightnesses of stars, he defined the magnitude scale so the ultraviolet and visual magnitudes would be the same for *A0*-type stars.

The appearance of the constellations is drastically altered in ultraviolet light, being dominated by hot blue stars, while cooler stars, even those very bright to the eye, lapse into inconspicuousness. In all, there are 218 objects brighter than ultraviolet magnitude +2.0, of which 84 per cent are *B* stars. Only a single star—the sun—has a spectrum later than *A1* among these 218.

The brightest object in the sky at 1249 angstroms is the sun, with an ultraviolet magnitude of −13.2 (instead of −26.7 visually). Second and third are the southern Wolf-Rayet stars Zeta Puppis and Gamma Velorum, at −3.0. Next come Spica (−2.7), Zeta Orionis (−2.5), and Alpha Crucis (−2.5). There are no fewer than 23 objects brighter in ultraviolet than −1.0, while visually only Sirius, some planets, the moon, and the sun exceed this value. But in Mr. Davis' sky the moon would be very inconspicuous, of the 5th magnitude, because of its low reflectivity in the ultraviolet.

Interstellar dust is much more effective in dimming the ultraviolet light from stars than it is at visual wave lengths. Therefore, the number of stars brighter than a given magnitude increases much more slowly with magnitude in the ultraviolet than in the visual and photographic regions of the spectrum. This interstellar absorption produces some uncertainty in the calculated magnitudes; apart from this factor, Mr. Davis believes them accurate to half a magnitude either way. His computations were based on the simple assumption that the stars radiate as black bodies, yet more accurate calculations that took into account detailed properties of stellar atmospheres gave nearly the same ultraviolet magnitudes.



An artist's conception (left) indicates the tremendous size of the Ohio State reflecting-type radio telescope. The 12-foot model is shown above, on the roof of a campus building, where it is used by Robert Nash, a graduate student, for solar and lunar observations at 1.2 centimeters.

A Master of Stellar Spectra

HARLOW SHAPLEY, *Harvard College Observatory*

THE PASSING of Walter Sydney Adams at the age of 80 on May 11th has taken from us an American astronomer of the first rank, who was director of Mount Wilson Observatory from 1923 to 1946. His influence was worldwide, and he was a leader in organizing the International Astronomical Union, serving as vice-president during World War II.

Born in Syria of missionary parents, Adams came to this country to study at Dartmouth and the University of Chicago. It was in 1904, when an assistant at the Yerkes Observatory, that he was invited by George Ellery Hale to join the staff of the newly established Mount Wilson Observatory, then growing into a world center of astrophysics.

The early days at Mount Wilson were not all roses. There were struggles with transportation, temperature, rattlesnakes, recalcitrant telescopes and mules, and the usual opposition that men and nature offer to pioneers. No one could have been better suited to assist Hale in his epochal endeavors than his young assistant, W. S. Adams, who came with F. E. Ellerman and G. W. Ritchie from Yerkes. Adams had that skill and grim tenacity such efforts require. He grew up with the instrumentation that has made more astronomical history than any other star-bound operation since Galileo. His own account of these early days was published in 1947 in the *Publications* of the Astronomical Society of the Pacific.

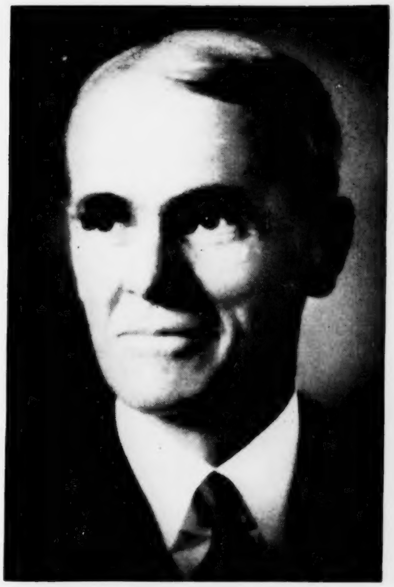
On the outside gallery of the 100-inch telescope at Mount Wilson Observatory, Dr. Adams is seen with Albert Einstein (left) during the latter's first visit there, in 1932.

Adams was a builder and a manager, but primarily an observer. Probably few men have devoted more hours at the eyepiece of a spectrum measuring engine than he, and for this devotion the stars owe him much. His catalogues of high-quality radial velocities will stand as a quiet monument, for Adams measured extensively the ordinary stars whose characteristics are needed against which to judge the more exciting exotics.

Although he was catalogue-minded, many spectroscopic highlights are his, for example, the difficult analysis of the spectrum of Sirius B, the most famous white dwarf. We probably have not had the last word on the red shift in the spectrum of that faint, exceedingly dense star, but Adams found that, in addition to its orbital motion, there is a line shift consistent with what we would expect from relativity theory.

The work of Adams, with Hale, C. E. St. John, and their colleagues, on the intricacies of the solar spectrum is historic. The rotation, eruptions, and other manifestations of that turbulent stellar surface were analyzed with increasing instrumental power. His study of planetary atmospheres with T. Dunham, Jr., is noteworthy, as is also his investigation of the contents of interstellar space, revealed by anomalies in the spectra of early-type stars. We were accustomed to the idea of interstellar calcium, and later of interstellar sodium. But Adams and his co-workers went much further, and the demonstration of interstellar heavy atoms such as iron has influenced the trend of cosmogony. The contents of "empty space" have become as important as stars and visible nebulosity.

The name of W. S. Adams will always be associated with spectroscopic parallaxes. He was the pioneer. He can rightly be called the father of that tremendously important extension of the Draper system of classifying stellar spectra. But when Adams first published on this subject in 1916, the criteria of absolute magnitude were not considered to require a second dimension in spectral classification. That concept was developed much later by W. W. Morgan and others. Forty years ago, however, it was nothing less than sensational to find that one could look at the dark lines of strontium in the spectrum of a distant star (for which the apparent magnitude had been measured) and announce its distance. Certainly the concept of spectroscopic parallax was one of the major early contributions from Mount Wilson Observatory. It took a keen eye and a keen mind to open that field.



Walter S. Adams (1876-1956).

Modesty was instinctive with Walter Adams. He strove to excel in everything he undertook—in endurance at the business end of a telescope, in quality of spectrum plates, in hiking speed up the mountain trail from Sierra Madre, in tennis, golf, billiards, bridge—and he did excel. But I never heard him call attention to his excellence. I remember complimenting him once on his designing the series of powerful and tricky spectrographs that were used in the Mount Wilson stellar and solar work. "It is a very low form of cunning," he replied.

INVESTIGATIONS IN STELLAR SPECTROSCOPY. II. A SPECTROSCOPIC METHOD OF DETERMINING STELLAR PARALLAXES

By Walter S. Adams

MOUNT WILSON SOLAR OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

Received by the Academy, February 8, 1916

The question whether the intrinsic brightness of a star may not have an appreciable effect upon its spectrum is one with important applications in astronomy. If two stars which have closely the same type of spectrum differ very greatly in luminosity it is probable that they also differ greatly in size, mass, and in the depth of the atmospheres surrounding them. Accordingly we might hope to find in these stars certain variations in the intensity and character of such spectrum lines as are peculiarly sensitive to the physical conditions of the gases in which they find their origin, in spite of the close correspondence of the two spectra in general. If such variations exist and a relationship may be derived between the intensities of these lines and the intrinsic brightness of the stars in which they occur, we have available a means of determining the absolute magnitudes* of stars, and hence their distances.

The first attempt to detect such lines was made by Hertzsprung, who concluded that the strontium line at λ 4077 gave some indication of varying with the absolute magnitudes of the stars in whose spectra it appeared. Quite independently Dr. Kohlschutter in the course of his studies of the classification of the Mount Wilson stellar spectra found two or three lines which appeared to vary in this way, and some results of an application of these lines to the determination of absolute magnitudes were published in 1914. Since that time the work has been extended greatly with the aid of the additional material available. The results of the investigation and of an attempt to utilize these criteria for the derivation of stellar distances are contained in this communication.

The Mount Wilson astronomer's classic announcement of a spectroscopic method for measuring star distances appeared in the March, 1916, "Proceedings" of the National Academy of Sciences. The first page of the paper is reproduced above.

☆ ☆ SKY AND TEACHER ☆ ☆

Sponsored by the
Teachers' Committee of the American Astronomical Society

A TEACHING UNIT IN ASTRONOMY – Grade 6

In elementary schools, astronomy is beginning to attract more and more attention as a specific area in science courses. This interest will continue to mount as the man-made satellite becomes a reality, and as the age of space travel approaches. However, the average teacher of elementary science is not well prepared for teaching a unit in astronomy; consequently, he wants definite information on what to do and how to do it.

To help fill this need, I have nearly completed preparation of a book, "Teaching a Unit in Astronomy, Grades 1 to 9." Based on the material in this book, I outline here a guide for the teacher of a 6th-grade class. As this is an intermediate level, suitable modifications should readily suggest themselves to teachers of higher and lower grades.

This month's installment covers the purposes, content, and activities for such a course; the second part (in September) will deal with materials, books, and teaching aids.

General Objectives

1. To aid the student in forming basic concepts of astronomy.
2. To encourage the student to discover astronomical facts for himself.
3. To stimulate pupils to become more observant of their starry environment.
4. To help the student visualize the earth's place in the universe.
5. To help combat astronomical superstitions.

Facts and Concepts

The Moon

1. The moon is the earth's nearest neighbor.
2. We see it by reflected sunlight.
3. The moon has about one fourth the diameter of the earth; it is 2,160 miles through it from one side to the other.
4. The moon turns (rotates) on its axis and makes one journey (revolution) around the earth in about 27 days.
5. The period of the moon's phases (time from one full moon to the next) is about 29½ days; this gives us the basis for the month in our calendars.
6. The moon always keeps the same face toward the earth.
7. Daytime on the moon lasts about two weeks and nighttime is also about 14 days long.
8. The moon changes its position in the sky from night to night; its apparent shape or phase changes also.
9. Many people still believe in false ideas (superstitions) of the effect of the moon on the earth.
10. Even with modern equipment, we have been unable to detect water or air upon the moon.
11. The moon rises 50 minutes later each night, on the average.
12. Most of the moon's visible surface is very rough, with many mountains and thousands of craters, some a hundred miles across.
13. The dark regions seen on the full moon are level areas called "seas" because the first observers thought they were oceans.
14. The craters were probably made by volcanoes or by meteorites hitting the moon.
15. The tides in the oceans of the earth are an effect of the gravitational pulls of the moon and the sun, chiefly that of the moon.
16. The moon plays a part in both kinds of eclipses: In an eclipse of the moon it passes through the earth's shadow; in an eclipse of the sun, the moon passes in front of the sun and hides it from our view.

The Sun

1. The sun is a star, but it appears large, and millions of times brighter than the other stars, because it is so close to us compared with them.
2. The sun's average distance from the earth is 93,000,000 miles.
3. The sun gives off light and heat in tremendous quantities.
4. All life on the earth depends on the sun.
5. Green plants use sunlight as energy in making food and fuel.
6. Sunspots are great "storms" on the sun.
7. When sunspots are most numerous, radio transmission on the earth and the earth's magnetic field suffer great disturbances. Sunspots are associated with the cause of the northern lights.
8. Like most other stars in the Milky Way system of stars, the sun is very large; it is big enough to hold over a million earths.
9. The sun is made of very hot gases; its surface temperature is about 11,000° Fahrenheit.
10. The spectroscope shows the sun to be composed of substances we know here on the earth.

The Solar System

1. The nine planets in order from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. A "word" to help remember them is M-VEM-J-SUN-(Pluto).
2. Each planet revolves around the sun in an orbit that is roughly circular; those nearest the sun move fastest.
3. Mercury takes only 88 days to go around the sun; the earth takes a year; and Jupiter, 12 years.
4. Many planets have moons (satellites); Jupiter has 12.
5. Jupiter is the largest planet, Saturn is the planet with rings, and Mercury is the smallest planet.
6. There is life on the earth, as we know. The only other planets that might have some form of life appear to be Mars and possibly Venus.
7. Comets and meteors are members of the solar system, too.
8. "Shooting stars" are really meteors, small pieces of material that fall into the earth's air and get very hot as they come down through it.

The Constellations

1. A constellation is an imaginary figure or picture formed by a group of stars. The Big Dipper is an example, although it is part of a larger constellation called Ursa Major, the Great Bear.
2. Most of the constellations were named long ago after heroes and animals; these star groups are the subjects of legends made up by early man.
3. The constellations that are above the horizon at night change with the seasons.
4. The constellations furnish astronomers with convenient divisions of areas in the sky, somewhat like states in the United States.
5. There are 88 constellations in the whole sky.
6. Some of the principal constellations are Bootes, Cassiopeia, Cygnus, Draco, Gemini, Hercules, Leo, Lyra, Orion, Scorpius, Taurus, Ursa Major, and Ursa Minor.

Activities and Experiences

1. Visit a planetarium, an observatory, or the home observatory or workshop of an amateur astronomer.
2. Organize an astronomy group or club.
3. Decorate the windows to make constellations by pasting gummed stars on them.
4. Collect pictures and articles on astronomy for the bulletin board. Look especially for articles on the proposed artificial satellite and on radio astronomy.
5. Observe the moon each night to see its changing phases; near the full phase note that the moon rises later each night.
6. A few days after new moon phase, look at the crescent moon in the western sky soon after sundown. Note that the rest of the moon (not the crescent) is dimly seen by earthshine. It is called earthshine because it is sunlight that is reflected from the earth to the moon and then back to the earth.
7. Make a collection of superstitions about the moon.
8. Demonstrate why the moon always keeps its same face toward the earth. This may be done by having a pupil walk around another pupil while continually facing him. When he gets around, he will have rotated once and revolved once.
9. Demonstrate the use of a prism to

show the colors of the sun's spectrum (rainbow colors). Hold the prism in the sunlight and turn it until the colors are seen on the wall of the room. A "word" used to help remember the order of the colors is ROY-G-BIV.

10. Make a study of the various planets. Use library references.

11. Make a sketch of the solar system. Show the sun in the center and then each planet in order in its orbit. (An excellent student might make a drawing to scale with the help of the teacher.)

12. Observe the moon with a pair of binoculars or a small telescope. Observe Jupiter in the same manner; some of the four bright moons of this planet may be seen near it.

13. With a globe, a ball, and a light, show how eclipses are caused.

14. Report on the great meteor crater in Arizona. Use library references.

15. Learn a number of star legends.

16. Locate a number of constellations by the use of star maps.

17. Make a star box to show the constellations. Glue the lid on a shoe box, or one of similar size, after cutting off the end of the box. Make a small hole in the other end to peep through. Make constellations by punching holes through sheets of paper cut to the size of the end of the box. Hold the constellation chart over the open end and look at it through the peephole, facing the window or an artificial light.

J. RUSSELL SMITH
Eagle Pass, Tex.

SPACE VEHICLES ON THE CAMPUS

"Orbital and Satellite Vehicles" is the title of a two-week intensive course offered at the summer session of Massachusetts Institute of Technology. Six hours of lectures and seminars daily, from August 6th to 17th, will deal with topics such as the astronomical background of space travel, rocket design and performance, new possibilities in propulsion, instrumentation of unmanned vehicles, and the physiological problems of man in space. Tuition for the course is $200; inquiries should be sent to the Office of the Summer Session, Room 7-103, M. I. T., Cambridge 39, Mass.

UTYU NO KAITAKU

Meaning "Cultivation of the Universe," this is the title of a collection in book form of translations into Japanese of articles from *Sky and Telescope*. Its 23 chapters are a selection from the volumes of 1950 to 1954, including 12 articles by Dr. Otto Struve and the Messier chart that was published in March, 1954.

The editor of this handsomely illustrated collection is Shigetsugu Fujinami, of the Kyoto University Observatory. The volume is priced at 290 yen.

Sky and Telescope has a few copies available for free distribution to subscribers who read Japanese.

Amateur Astronomers

Western Amateur Astronomers to Meet in Flagstaff

THE EIGHTH annual convention of the Western Amateur Astronomers will be held in Flagstaff, Ariz., from Wednesday through Saturday, August 29th to September 1st. The first three days will be devoted to WAA activities, and on the last day the Association of Lunar and Planetary Observers will have an informal meeting that will be open to everyone in attendance at the convention.

Flagstaff, noted for the Lowell Observatory, where observations of Mars have been carried on for over 60 years, is a growing center of astronomical activity. It is the site of the new 40-inch reflector station of the U. S. Naval Observatory, to which a field trip is scheduled for the convention. A trip will also be made to nearby Barringer meteor crater.

The main observing interest at the convention will be Mars, whose nearest approach to the earth will occur about a week after the close of the meetings. There will be two star parties, one at Arizona State Teachers College and the other at Lowell Observatory, where everyone attending will have a rare opportunity to observe Mars through its large instruments.

Among the speakers at the convention will be Dr. Otto Struve, director of Leuschner Observatory and this year's recipient of the G. Bruce Blair medal; Dr. Albert G. Wilson, director of Lowell Observatory; and Clyde W. Tombaugh, veteran amateur observer of Mars and discoverer of the planet Pluto.

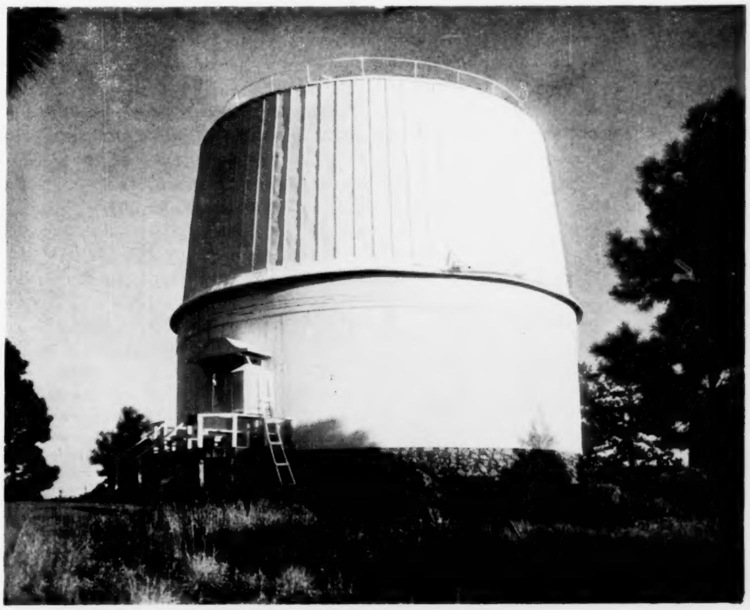
The sessions will be held in the Flagstaff high school. There will be many papers by outstanding amateur astronomers, dealing with observing, telescope making, and general astronomical topics. All interested persons may attend, and are invited to bring instruments and display material for exhibition purposes. T. A. Cragg, 246 West Beech Ave., Inglewood, Calif., can supply further information about exhibits and the convention program.

According to the Eastbay Astronomical Society *Monthly Bulletin*, San Francisco area amateurs interested in traveling to the Flagstaff meeting in a chartered Greyhound bus may contact H. M. Cochran, 50 Albion St., San Francisco 3, Calif., for further information.

NORTHWEST CONVENTION

The Northwest Region of the Astronomical League will hold its annual convention in Yakima, Wash., Sept. 1-3. The host society is the Yakima Amateur Astronomers, which hopes to have both its $12\frac{1}{2}$- and 16-inch telescopes completely mounted for display and observing.

The plans call for a star party at a



At Lowell Observatory, a cylindrical dome houses the famous 24-inch refractor, with which western amateurs will have an opportunity to view Mars during the August convention. Excellent optical qualities and an unusually favorable site, 7,250 feet above sea level in the great pine belt of Arizona, make this a very effective telescope for planetary work.

high altitude, and a convention banquet, in addition to the usual sessions for papers. The registration fee of $1.00 may be sent in advance to the society at 324 W. Yakima Ave., Yakima, Wash. Information about hotels and other accommodations will be provided to anyone interested on request.

ORLANDO, FLA.

Organized in November, 1954, the Amateur Astronomy Club of Orlando presently has 16 active members and one honorary member. He is Dr. Laban Lacy Rice, who recently published a manual for amateurs, and has written other books. About 15 visitors also attend each of our meetings.

Our members own 12 telescopes, eight of them from 4- to 8-inch reflectors, and the others 2- to 5-inch refractors. We meet on the second Thursday of each month at the Edgewater High School. We would appreciate correspondence from other clubs.

L. A. TALLEY
435 Jersey Ave.
Orlando, Fla.

MACON, GEORGIA

With the help of our local newspaper, which ran an article on the editorial page, we held our first meeting on the last Friday night of November. The Macon Amateur Astronomers Club now has 22 active members.

Among the telescopes used by our members is a 2.4-inch equatorial refractor owned by the club. We meet every other Thursday night at my home. We have arranged to give weekly talks and telescope demonstrations for the six-week boy scout camp this summer.

GRADY WOOD
Rt. 1, Riverside Drive
Macon, Ga.

BALTIMORE, MD.

The Baltimore Astronomical Society, originally founded in 1881, joined the Maryland Academy of Sciences as its astronomical section in 1900, but its meetings were discontinued during World War II. At a meeting on April 10th this year, the group was reactivated.

Some 62 amateurs joined the society, a constitution was adopted, and the following officers were elected for one-year terms: Paul G. Crout, president; Paul S. Watson, vice-president; and Mrs. Gloria Stolberg, secretary-treasurer.

Meetings will be held on the third Monday of each month at 8 p.m. in the auditorium of the Enoch Pratt Library, Franklin and Cathedral Sts., Baltimore, Md. All interested persons in the Baltimore area are invited to attend.

SCOUTS' ASTRONOMY MONTH

The Boy and Cub Scouts of America have designated January, 1957, as an astronomy theme month. At a recent meeting of planetarium directors at the American Museum-Hayden Planetarium in New York City, material was prepared which the national Boy Scout headquarters will disseminate to all local scout groups.

This material included a condensed and simplified list of 1957 celestial events; suggested projects and experiments for individual and group work; proposed reading matter for all age groups; sources for photographs, films, and filmstrips; and reference material on artificial satellites.

Scout troops will be encouraged to contact amateur astronomy societies, planetariums, and observatories in their respective areas for further assistance.

STELLAFANE PROGRAM

Preceding this year's meeting of telescope makers at Springfield, Vt., two optical plants in New England will open their facilities for inspection: the American Optical Co., Keene, N. H., on Friday, August 10th, from 1:00 to 4:00 p.m., and the Optical Comparator Division of the Jones and Lamson Machine Co., in Springfield, on Saturday, August 11th, from 9:00 a.m. to noon.

Later that day, at Stellafane itself, of particular interest to amateurs will be talks and discussions on radio astronomy and the artificial satellite. Dr. Robert Fleischer, Rensselaer Polytechnic Institute, will describe the construction and mounting of 10-foot radio telescope antennas. In the evening, beginning at 7 o'clock, there will be talks by Dr. J. A. Hynek, Ohio State University; Dr. James G. Baker, Spica, Inc.; and Dr. Gerald Hawkins, Harvard Observatory.

During the evening's observing, instruments brought by amateurs will be judged for quality and performance. The registration fee of $2.00 may be sent in advance to James W. Gagan, ATM's of Boston, Harvard College Observatory, Cambridge 38, Mass. The Boston group and the Springfield Telescope Makers are cosponsors of the meeting.

As in past years, the meeting is at Breezy Hill, three miles from Springfield, Vt. Hotel and room reservations may be made through Mr. Merryfield, Hartness House, Springfield. Overnight camping space is also available.

LETTER TO THE EDITOR

Sir:

My husband and I would like to know if amateur astronomy is the noisiest hobby in the world, outside of drag racing. Living as we do in the Santa Clara Valley, we have always associated astronomy with the quiet dignity of Lick Observatory on top of Mt. Hamilton. That is, before the people next door took it up.

The noises from do-it-yourself neighbors are considered quite normal here and occupy most of those hours known as "waking." So we were not quite aware what was going on when a big silver dome, jiggling like a drunkard's hat, appeared above our fence. It was being jockeyed into position on what we had fondly regarded as the beginning of a child's playhouse.

Five nights later, or rather mornings, we had our answer in the screech of tortured metal and a reverberating crash, which tossed us from our beds! But this was just the beginning.

At regular intervals our nights have been jolted with rumblings and squealings from a poorly adjusted dome, and with loud exclamations which we interpreted as the mating call or fraternal password of a species new to us:

"Hey, four bands! Look at this, four bands!" or "M13, heck! It doesn't look much like the picture in *Sky and Telescope!*" or "Copernicus? No, that's Tycho."

However, now that we've found it is all in the name of science we've decided to put up with it. Besides, we're invited over at three o'clock tomorrow morning to look at Saturn, which is the one with the ring, we think.

MRS. MYRTLE MURGATROYD
San Jose, Calif.

"Our neighbors are making minor adjustments on their dome." —Mrs. Murgatroyd.

(This photograph by Thomas Nelson, Jr., and the accompanying letter have been transmitted by anonymous members of the San Jose Amateur Astronomers.)

BOOKS AND THE SKY

THE SUN AND ITS INFLUENCE

M. A. Ellison. The Macmillan Company, New York, 1955. 235 pages. $4.50.

IT IS not often that an astronomical book is published at a time when both cosmic events and the affairs of man conspire to show the need of the new volume. Such, however, is the auspicious background against which this book has appeared.

The current rapid rise toward maximum in the solar cycle and the expanding plans for solar observations during the International Geophysical Year point to the need for a sound and comprehensive summary of solar phenomena and the terrestrial effects attributed to them. Dr. Ellison's new book provides exactly this information, and large sections carry the authority of direct experience, for Dr. Ellison has been observing the sun for many years. He is the principal scientific officer of the Royal Observatory, Edinburgh, and serves in an active capacity on the solar commissions of the International Astronomical Union.

The author expresses the hope that the treatment of the subject is "neither too advanced for those with a knowledge of elementary physics, nor too simple to be read with profit by workers in other sciences." In this dual goal he has eminently succeeded. For the reader not yet familiar with solar astronomy, there is the introductory subject matter of the first chapter, "The Sun and Its Radiation." Also, throughout the entire volume there is a continuing consideration of the reader's possible need for specific definition and explanation of terms and concepts. The lucid style in which the book is written further assists the nontechnical reader in understanding complex solar phenomena.

For the specialist as well as for the general reader, Chapters II to V give valuable summaries of the various aspects of solar activity, a description of the earth's ionosphere and its variations, and a presentation of the manifold ways in which solar flares affect the earth. Much of this material has hitherto been available only in specialized texts or in research articles. The author writes with clarity, and with authority and humility that come from long, direct experience with solar phenomena. In his own words, "The account is mainly factual; for, in solar-terrestrial relations, as in other branches of astronomy, speculation tends to outdistance verifiable knowledge."

Each of the remaining four chapters deals with a special aspect of solar-terrestrial relations: the earth's magnetism, the aurora, radio radiation from the sun, and cosmic rays. For each of these subjects, a survey of the most recent information follows a brief historical introduction. Throughout the book, photographs and well-designed line drawings assist in the presentation of ideas and observations. In the interest of brevity, the author has at times omitted supporting details or discussion that might have amplified or clarified the subject. This difficulty is partially mitigated by the carefully prepared bibliography that is given for each chapter.

I believe that Dr. Ellison, in his discussion of "flare surges" on page 116 and in his use of the limb flare of May 8, 1951 (Plate VII), to illustrate this phenomenon, has probably misinterpreted the reviewer's study of the great solar event that took place on that date. It is entirely true, as the author states, that surge-type prominences frequently accompany flares, and the flare of May 8, 1951, was no exception. In this case, the surge or ejection rose to a height of at least 200,000 kilometers with a velocity of the order of 500 kilometers per second. However, this surge is not visible in the spectroheliograms reproduced in Plate VII. Because of large Doppler shifts, the surge was even fainter through the narrow slits with which the spectroheliograms were made than was the quiescent prominence faintly visible in Plate VII to the left of the bright flare.

Although most flares are relatively low-level features, there is growing evidence

that a small number of them may be elevated phenomena. The flare of May 8, 1951, is considered to be such a case. During the sudden ionospheric disturbance that began at 15:06 UT on that date, the bright elevated phenomenon shown in Plate VII was the only visible hydrogen-alpha solar feature with the flarelike characteristics of sudden change and great brightness. Photometric measures show that it was as bright in hydrogen light as are the brightest flares observed on the solar disk. The reviewer realizes that this was an unusual flare, perhaps so much so that Dr. Ellison could hardly believe it.

One of the great merits of Dr. Ellison's book is the way in which he makes the reader realize that solar research today is a very active and rewarding field of investigation. The problems are of intrinsic concern and worthy of one's highest endeavor. Many of them have implications beyond their immediate statement. Practically all of them are unsolved. It is the reviewer's belief that *The Sun and Its Influence* may well be the touchstone by which potential astronomers and physicists in our college classrooms become aware of the rapidly developing importance of solar research and accept the challenge that it presents.

HELEN W. DODSON
McMath-Hulbert Observatory
University of Michigan

A POPULAR GUIDE TO THE HEAVENS

Sir Robert Ball. Fifth edition, edited by E. A. Beet. George Philip and Son, Ltd., 30-32 Fleet St., London E.C. 4, 1955. 84 pages plus 83 plates. 30s.

BY THE TIME a book has reached its fifth edition after more than 50 years of use, little can be said about it that has not been covered by others. This volume includes a summary of our knowledge of the solar system, a guide to the positions of the planets to 1970, photographs and drawings of celestial wonders, and a list of objects that should be interesting in a small telescope.

The present editor is Ernest Agar Beet, secretary of the British Astronomical Association and a member of the faculty of the Pangbourne Nautical College. He points out that the last revision in 1925 was very thorough, that he has corrected statements that are no longer true, and that he has added a few words to indicate the direction new knowledge is taking.

Measures of double stars have been revised to more modern values, while a new map of Mars with notes concerning that planet has been added. Certain astronomical discoveries made between the time of revision and the date of publication are shown in an addendum following the preface.

This work is highly recommended for the ambitious amateur who wishes to dig deeper into the subject. Your reviewer was inspired by the first edition of this book, and he is happy to add the new edition to his library.

Since the text consists of facts and figures rather than theories, some of the older sections have not been reset and missing letters indicate that the type is becoming worn. The next reviser might check the use of the term "Palomar" rather than "Mount Palomar," and he should substitute "galaxy" for the mouth-filling and misleading "extragalactic nebulae," a term that is used too frequently in this book.

ROY A. SEELY
New York, N. Y.

MARIA MITCHELL
Girl Astronomer

Grace Hathaway Melin. Bobbs-Merrill Co., Inc., Indianapolis, Ind., 1954. 192 pages. $1.75.

LIKE some 90 other books of the series, "Childhood of Famous Americans," this book is popular with children between 8 and 12, who think that they are learning facts about the first woman astronomer in America. But they are getting merely a fanciful sketch of a child who resembles the real Maria Mitchell only to the extent that she has an inquiring mind, is eager to study mathematics and astronomy, and helps with the housework. In the first 12 chapters, her first

day at school is the only incident founded on fact.

The author fails utterly to depict Quaker children or Quaker parents of the Nantucket of the early 19th century. What child of that day would have been allowed to "make a face" or "stick out her tongue" when she wanted to gain a point over a brother, sister, or playmate? And certainly at the age of 30 Miss Mitchell would not have made a face at Professor George Bond. No one who has examined the original material available could have attributed to her father William Mitchell the horseplay and other actions described in this book.

Portions of the last four chapters are factual, but there are many inaccuracies interspersed with fiction. The solar eclipse of February 12, 1831, was annular, central 16 or 17 miles north of Nantucket. According to the record the sky remained fairly bright; no artificial light was needed to read the chronometer and record the times of the contacts. The planet Venus could be seen at mid-eclipse, but no stars were visible. From his observations, Mr. Mitchell determined the longitude of his house on Vestal Street, a value necessary in his work of correcting chronometers for the whalers. No prize money came with the gold medal which Maria Mitchell received from the king of Denmark.

The "star pictures" described in chapters 7 and 9 and some of the rudiments of astronomy are well done, in language easy for children to grasp. One wishes that the author had published only a brochure of these, and had left the biography to someone willing to take time to ferret out and write facts.

There is need for a good child's life of Maria Mitchell, one as vivid and accurate as the beautifully written *Sweeper in the Sky* by Helen Wright, describing for adults the life of the pioneer woman astronomer and educator. Miss Wright's researches for her book took her far afield and occupied the major part of 10 years. During that time she learned to know Nantucket and its traditions. She gleaned from persons who have since died most of the stories she used about Maria Mitchell's childhood. It is hoped that before long she will find time to write a child's book on this subject.

MARGARET HARWOOD
Maria Mitchell Observatory
Nantucket, Mass.

IONIZED GASES

A. von Engel. Oxford University Press, New York, 1955. 281 pages. $6.75.

THE subject matter of this text is usually described as the discharge of electricity in gases; the entire book is devoted to problems concerning electric currents flowing in gases.

The possible applications to astrophysics and particularly to the physics of the upper atmosphere are numerous. And

SMITHSONIAN ASTROPHYSICAL OBSERVATORY

BULLETIN FOR

Visual Observers of Satellites

NUMBER 1 | 60 GARDEN STREET, CAMBRIDGE 38, MASS. | JULY, 1956

A Message to Volunteer Observers:

The satellite program of the International Geophysical Year offers a unique opportunity for the volunteer visual observer to make a significant scientific contribution. On him will rest the responsibility for obtaining the first and the last scientifically valuable visual observations of the satellites. Such observations will support the early radio tracking, and will probably be the only observations available of the dying satellite. The visual work will have particular importance for the calculation of the density of the upper layers of the atmosphere near the limit of measurements obtained with modern high-altitude rockets.

FRED L. WHIPPLE

The early satellite tracking is necessary for the calculation of preliminary satellite-finding ephemerides, essential to aiming the photographic Schmidt telescopes that will make the precision observations of the satellites. Should a satellite's radio fail or some satellites be launched without self-contained radios, the full weight of responsibility for the critical initial observations of the satellite will fall on the shoulders of the volunteer visual observers.

The earth satellite program has been developed by the U. S. National Committee for the International Geophysical Year. This Committee was established by the National Academy of Sciences to plan and direct the IGY program of the United States, and to coordinate our efforts with those of some 46 other nations, through a special international committee set up by the International Council of Scientific Unions. Thus the satellite program is part of an unprecedented study of the earth and its atmosphere, in which the principal scientific institutions and the leading geophysicists of the world are involved.

The National Academy of Sciences, through the National Science Foundation, has assigned to the Smithsonian Astrophysical Observatory the initiation of an optical tracking program for the earth satellites. A vital part of this program can be carried out only by a corps of qualified visual observers, who in organized groups will man selected strategic observing stations.

We hope that publication of this bulletin from time to time will act as an effective means of dissemination of authoritative information about the progress of the satellite program, methods and means of observing and reporting, and related topics.

We at the Smithsonian Astrophysical Observatory are grateful for your co-operation. The work required of the volunteer observer will be exacting and time consuming; but it will confer that most satisfying of all rewards to the person interested in science: the knowledge that he has contributed significantly to a unique international scientific effort of prime importance.

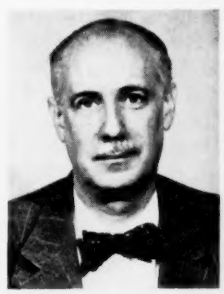
FRED L. WHIPPLE, Director
Smithsonian Astrophysical Observatory

J. ALLEN HYNEK, Associate Director
of the Satellite Tracking Program

A Note from the Coordinator:

The story of the satellites to be launched during the International Geophysical Year is in itself so dramatic that it requires no special promotion to awaken universal interest. Virtually every human being with ordinary curiosity and a spark of scientific imagination will want to see the satellites.

The *Bulletin for Visual Observers of Satellites*, addressed to the volunteers who have registered with the coordinator or with members of the advisory committee, will be issued from time to time. The information in the bulletins will be carefully checked for accuracy by Dr. Whipple, director, and by Dr. Hynek, associate director of the satellite tracking program.



ARMAND N. SPITZ

Even though this bulletin for visual observers will present the facts as exactly and precisely as possible, it cannot forsee all the problems that may arise; my office will undertake to answer necessary questions and to provide interpretation of difficult material. The bulletins may be kept in a spring binder or loose-leaf folder, together with supplementary information, so that the file, when complete, should contain the answers to practically all questions that may be raised about observing the satellite.

The code names MOONWATCH and SEESAW have both been suggested for the visual observing pro-

gram. MOONWATCH is obviously appropriate, and SEESAW, because of the extremely rapid motion of the satellite, will apply in the sense of "I see it—I saw it!" In this bulletin, for the present, the word MOONWATCH will be used.

Many thousands will probably wish to volunteer to observe the satellite; a large part of these will lack the necessary qualifications, and even of those qualified only a relatively small number will be able to spend the time and energy necessary to play a useful part in the observing program. Before the teams of visual observers can be finally chosen, an extended period of time will be required for the screening and training of volunteers, for experiment with various procedures, and for organization and practice. Therefore, the selecting of volunteers is beginning now.

Skilled and reliable volunteers will be needed to observe a satellite in such rapid motion. Each individual will carry a heavy responsibility toward the success of the total program. Each group, and every member of the group must be completely dependable, if the sum of the observations is to achieve our purpose. The coordinator and advisory committee will therefore establish basic qualifications and requirements. Every volunteer must meet these requirements before he can be formally accepted as a group member.

Members of the advisory committee, whose names and addresses are listed on the last page of this bulletin, are ready to receive applications from amateurs seriously interested in taking an active part in the program. But please assist the committee in its very demanding task by limiting your queries to those that are *specifically connected with the observing program.*

We invite participation by amateur astronomers who recognize in this project an unusual challenge, as well as the opportunity to establish a new and productive relationship between the amateur and the professional astronomer.

ARMAND N. SPITZ
Coordinator of Visual Observations

I. The MOONWATCH Program

A. Objective. The primary objective of the visual program is to make sure that an observable satellite will not pass over a station without being observed with acceptable accuracy. This objective can certainly be attained, but it will depend heavily on the MOONWATCH groups—their number, size, and reliability.

B. Organization. A central computing bureau for receiving and evaluating optical observations will be established, probably at the Smithsonian Astrophysical Observatory, on the grounds of Harvard Observatory in Cambridge, Massachusetts. The observing groups in any given geographical area will be informed when an observable satellite may be expected in their region. The system of notification has not been completely worked out, but it may involve the use of radio, television, telephone, telegraph, cable, news releases, and air mail. When a group leader is informed that during an approaching twilight period a satellite is expected to be observable from his station, he will have the responsibility of notifying the members of his group and readying them for action.

C. Individual Qualifications. The central computing bureau will accept only the observations dispatched by a group leader, and the group leader will accept and forward only observations made at the site chosen for his particular group. Thus, no "lone-wolf" observer can contribute usefully to the program; each individual must act in co-operation with his group, if his observations are to have any value. All observations by a group must, in turn, be made from a stated geographical position, as predetermined and recorded at the central computing bureau (in the memory system of the computing machine).

These very rigid requirements are essential for several reasons:

1. A precise observation of a satellite's position in the sky is worthless unless the observer's geographical position is accurately known at the computing center for immediate use in the calculations.

2. The computing system can deal with only a limited number of such known stations, and it will not be feasible to investigate reports from isolated observers to determine their possible value.

3. The satellite program depends on the volunteer observing groups to constitute a series of "optical fences," to prevent any possibility that a satellite might slip through successive zones of observation without being seen. Even if it were possible to screen the scattered reports of isolated volunteers, the number of such observers would have to be impossibly large to guarantee that the satellite would be detected by their unorganized search.

D. Group Organization. Each qualified group will be under the direction of a leader, with an assistant leader, who may double as timekeeper and recorder if the group is limited in numbers. Each observer in a group must have a pair of binoculars or a monocular, of wide aperture and field, supported on a mounting that can be directed to a chosen region along his meridian. The most efficient instrumentation will be described in a later bulletin. With binoculars or monoculars whose fields overlap along the meridian "fence," some 30 observers for each station will be an optimum number to cover the arc of the meridian over which useful observations might be made. A much smaller group, however, can do useful work; the most suitable instrumentation will depend on the number of observers in the group.

A short-wave radio to give accurate time signals is almost indispensable. If some type of recording equipment, such as a tape recorder, is available, an immediate and permanent record can be made of time and other data. Stop watches or other types of second-indicating timepieces must be used to supplement even a radio and recording system.

E. Operational Procedure. The group leader will assign to each observer a fixed area of the sky along the meridian, so chosen that adjacent fields will overlap

suitably. During the observing period, each observer should fix in mind the configurations of fainter stars as they slowly pass across his field of view. In this way he will be able to report the precise path of a satellite across the field, if he is so fortunate as to be watching that part of the meridian over which it passes. On seeing a satellite, the discoverer will make a signal to the timekeeper and recorder to warn them that he has spotted the satellite and to prepare them for an accurate time determination.

The discoverer *must not* move his telescope to follow the motion of the satellite. The group leader and assistant group leader should be able to confirm the reality of his observation by means of their own movable binoculars. The discoverer's immediate duty is to reconstruct, as accurately as he can from his memory, the exact track of the satellite among stars in his field of view, marking it on a chart of the configuration, after determining as well as possible the instant of passage across an identifiable star group.

If the group leader is convinced that the observation is authentic, and not some passing aircraft or some other spurious target, he will ask certain other observers to follow the satellite's motion and attempt to produce an accurate record of its path among the fainter stars, calling times at points along the sky that can be located with respect to the star background.

The group leader, at the earliest possible moment, will transmit the observations to the central computing bureau by some rapid means, and the computing machine will immediately incorporate the observations into an improved solution for the motion of the satellite. All significant observations will eventually be published, and each will bear the name of the observer and of the group leader as those responsible for its authenticity.

When a satellite is near perigee and therefore brightest, the twilight watching period need not exceed an hour; when the satellite is near apogee and moving slowly, the watch may exceed two hours. It is even remotely possible that a satellite may be observed twice during one observing period.

This brief description of the procedure to be followed by an observing group indicates the nature of the problem, as well as the methods needed to insure that a satellite cannot pass by unobserved, and that, when it is observed, the time and position will be determined with the necessary accuracy. Many variations in the details of the observing procedure are possible, and ingenious improvements may be developed by many groups during their training periods. These should be reported to the national advisory committee for analysis and possible general distribution to other observers.

II. Basic Facts About the Satellite Orbits

According to present plans, the first satellite will be a polished metal ball, 20 inches in diameter, traveling in a slightly eccentric orbit inclined between 30 and 40 degrees to the earth's equator. The eccentricity will be only about 0.07, but it should be remembered that this is measured with respect to the center of the earth rather than the surface. At perigee the satellite should travel about 200 miles above the earth's surface, and at apogee some 800 miles. With a mean altitude of about 500 miles, its period, which is a function solely of its mean distance, will be about 100 minutes.

The motion of the satellite through the observer's sky will be rapid in comparison to the speed of all other celestial bodies, except meteors. A satellite will cross the entire United States in only 10 minutes; and on its closest approach to the earth it will appear, to an observer directly beneath it, to move at a rate of about 1.3 degrees per second of time. When at apogee or at lower meridian altitudes, its apparent rate will be reduced to a small fraction of a degree per second. For comparison, the apparent speed will be equivalent to that of an object crossing the face of the moon in from half a second to a very few seconds.

None of the satellites now planned will be a conspicuous object. The average apparent visual magnitude under favorable circumstances will be approximately 7, depending upon the exact size, reflecting power (albedo), and the distance. When at perigee and directly overhead the satellite may be a magnitude brighter, and at apogee or at a low meridian passage, as faint as 9th or 10th magnitude.

The inclination of the satellite's orbit to the earth's equator will be equal to or somewhat greater than the latitude of the launching site, which will probably be about 28° north, at Patrick Air Force Base near Cape Canaveral in Florida. The firing must be directed over water where shipping has been suspended, so that the heavy motors of the first and second rocket stages will not endanger human life or property when they fall. Observations, however, should be made from land, so the trajectory will probably follow the northern edge of the Bahamas in a direction somewhat south of east. The generally eastward direction is highly desirable, for the entire rocket can gain speed from the eastward rotation of the earth, which is about 900 miles per hour at that latitude. Thus the inclination to the equator will exceed 30 degrees, and it is hoped that the value will be nearer 40 degrees.

Observers located somewhat outside of the latitude zones equal to the inclination of the orbit may still have a good chance of seeing a satellite, but it will appear somewhat fainter and be closer to the horizon than for observers in latitudes where it can pass overhead.

We do not know how long a satellite will remain aloft. Several months is probably a safe guess. When we have answered this question we shall have solved one of the most important problems to be attacked in the early part of the satellite program—the density of the very uppermost regions of the earth's atmosphere. Even though that density may be one millionth of a millionth of the air density at sea level, its resistance will still cause the satellite to spiral slowly inwards. The rate of spiraling will be directly pro-

portional to the air density, so observations of the satellite will give a quick direct measure of this still unknown quantity. Rocket observations, incidentally, can give us measures only up to about a hundred miles above the earth's surface. Observations of a satellite near the end of its spiral, when its orbit is changing rapidly, will then serve to tie together these two modes of measuring the density of the earth's high atmosphere. Temperatures can be calculated from these measures, but will depend upon assumptions or other measurements of the atmospheric composition.

If the earth were a perfect sphere, the satellite would continue to move in a fixed plane with respect to the stars except for the very small perturbations introduced by the moon and the sun. But a satellite moving so close to the earth's surface is overwhelmingly within the gravitational power of the earth, and any major shifts in its orbit must arise from the peculiar distribution of mass in the earth.

Since the earth's equatorial diameter is greater than its polar diameter, the equatorial bulge causes a variable gravitational pull on the satellite as it moves around the earth. Except in the case of a satellite moving exactly in an equatorial or polar orbit, the plane of the orbit will keep swinging around in the direction opposite to that in which the satellite moves. Measured with respect to the stars, the intersection of this plane with the earth's equator will move westward around the equator with a period of some 50 days.

This motion of the orbital plane, combined with the rotation of the earth and the motion of the earth about the sun, presents a rather complicated geometrical picture. Furthermore, a satellite can be observed optically only when it appears during evening or morning twilight, for then it is illuminated by the sun and the observer is in shadow. Thus, the circumstances for observation become rather difficult to visualize. The serious reader may wish to construct a simple model of the earth, sun and satellite, to help him follow the changing observational zones.

This model may be made from a small school globe, a flashlight (for the sun) fixed at a few feet from the globe, and a wire hoop that is only slightly larger than the globe's diameter. If the hoop is held in such a way that its plane passes through the center of the globe and is inclined about 35 degrees to its equator, it constitutes a good representation of the satellite orbit. If the entire model is placed in a darkened room, the flashlight creates the zones of twilight on the globe in which an observer might expect to see the satellite. The satellite will make about 15 revolutions while the earth turns once with respect to the sun. The north and south motions of the zones of observability appear quite clearly as one turns the plane of the hoop around in a westerly direction; for an actual satellite, one turn requires about 50 days.

Another way to visualize the situation, with or without the model, is to adopt the satellite's point of view. Suppose we are moving with the satellite and looking down at the earth. Underneath us we shall observe, in succession, the daylight side of the earth, the evening twilight zone, the night side, the morning twilight zone, and again the daylight side. We on the satellite see all of this happen in only 100 minutes of actual time, so the earth can turn only 25 degrees during one revolution of the satellite. As the plane of the orbit swings around during the 50-day cycle, the area where the satellite crosses a twilight zone, and is thus observable, will move rhythmically up and down in the earth's latitude from the point farthest north to the point farthest south and back again. When a twilight crossing is at a northern latitude in the morning, it will occur at a southern latitude in the evening. When a morning crossing occurs near the equator, so also will the evening crossing. The seasonal change in the position of the earth with respect to the sun will affect this geometry considerably, without changing greatly the available time for satellite observations.

During our 100-minute motion around the earth, the earth will have turned some 1,700 miles eastward at the equator, and the satellite crossings will take place at longitudes about this far apart.

If a twilight crossing takes place near perigee, 200 miles above the earth's surface, the sun's shadow will just about reach the meridian directly over the observer's head at the end of evening twilight or at the beginning of morning twilight. Specifically, we shall have about 40 minutes during fairly dark skies to catch a satellite as it passes overhead in these circumstances. On the other hand, at apogee the satellite is far above the earth's shadow for a considerable angle in the sky beyond the direction of the sun at the level of twilight. Hence, we shall then have more than 100 minutes of good dark sky in which we may hope to observe the satellite. This gives the opportunity, on rare occasions, to observe the satellite twice during one twilight period, as already mentioned.

Future issues of the bulletin will contain more specific information on details of observing procedure and additional data about the satellite which will be useful to our volunteer observers.

SMITHSONIAN ASTROPHYSICAL OBSERVATORY
I.G.Y. Satellite Optical Tracking Program

Please address all visual observing applications to any individual member of the committee.

the experimentalist whose electronic equipment depends upon arcs, glow discharges, and the like, may obtain herein an improved insight into the background physical phenomena.

The sections on the production of charged particles, charge transfer, diffusion, and recombination are of greatest direct geophysical or astrophysical interest; those on ionization in an electric field, glow and arc discharges, secondary emission, and so forth, are of more immediate concern to the electronics specialist.

A distinctive feature of this book is its emphasis on the physical picture of the phenomena described. Simple classical arguments are often given, and the results of the much more complicated quantum mechanical calculations (treated, for example, in Mott and Massey, *Theory of Atomic Collisions*) are described briefly. Many numerical illustrations enliven much of the discussion and contribute greatly to the reader's appreciation of the order of magnitude of the quantities involved.

The experimental procedures employed in the measurement of ion mobilities, charge-transfer cross sections, diffusion and recombination coefficients, and temperature distributions in discharges, are described.

One fact that will impress the astrophysical reader is the much greater complexity of physical processes in gaseous discharges than, for example, in media of extremely low density. On page 44 the author enumerates a variety of ways in which atoms may leave metastable levels, without even mentioning the mode which is most important in so many celestial bodies—the emission of forbidden lines!

The complexities of gaseous discharges would appear to put them at some disadvantage as a tool for astrophysical research until these processes are more completely understood. The luminous shock tube offers, under certain circumstances, an experimental setup where the physical state can be approximated as a function of time by a series of states of thermodynamic equilibrium. Nevertheless, the great success of the Kiel work with the whirling water arc promises many important further contributions by essentially gas-discharge techniques.

The experimental and theoretical literature in the field has become so extensive that a volume of this size cannot be expected to contain all that a particular specialist might want. A list of useful references is appended at the end of the volume.

Unfortunately, no account is given of the extensive investigations by H. S. W. Massey, E. H. S. Burhop, David Bohm, and their associates, and by others on the properties of gaseous discharges in magnetic fields. In view of the many astrophysical problems concerned with ionized

gases in magnetic fields, this omission is to be regretted. Perhaps such subjects will be handled in a later volume.

Certainly, problems concerned with electrical conduction in gases are going to be of increasingly greater interest to astronomers in the years to come, and von Engel's book can be recommended as an introduction to this rapidly developing subject.

LAWRENCE H. ALLER
University of Michigan Observatory

A MARINER'S METEOROLOGY

Charles G. Halpine and H. Hagen Taylor. D. Van Nostrand Co., Inc., Princeton, N. J., 1956. 371 pages. $8.00.

THE DEDICATION: "To you, with a wish that its study will enrich your knowledge and appreciation of the phenomena of the ever-changing weather around us," strikes the keynote of this textbook, which is used to teach meteorology to future officers at the U. S. Naval Academy.

After a description of the characteristics, composition, and structure of the atmosphere, the authors discuss the elements of meteorology and their measurement. No use is made of advanced mathematics nor of higher physics that might be confusing to a sailor.

There is an explanation of a *station model*, the cluster of symbols on a weather map telling the conditions at a reporting station; the proper use of these observations is described. The subsequent chapter on cloud types and obstructions to vision is so well illustrated with photographs of various clouds that the average layman ashore will be as interested as the mariner.

The table of wind force on the Beaufort scale is accompanied by excellent photographs of the sea when winds of various speeds are blowing. Yachtsmen and small-boat sailors will be interested in the explanation of small-craft storm and hurricane warnings. There is a description of radio aids for ships at sea, including the international analysis code, of importance to small ships.

Weather maps and forecasts are explained in great detail, and there is a series of maps for one complete day, at six-hour intervals, to show the practical application of many of the factors in forecasting. The book concludes with chapters on climatology, oceanography, and weather at war. The final glossary of technical terms will prove most helpful to both casual readers and students. There are review questions at the end of each chapter.

This book is really designed around its many excellent pictures and diagrams, and it will stimulate the reader to put into immediate practice the knowledge he has assimilated so pleasantly.

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Harvard College Observatory

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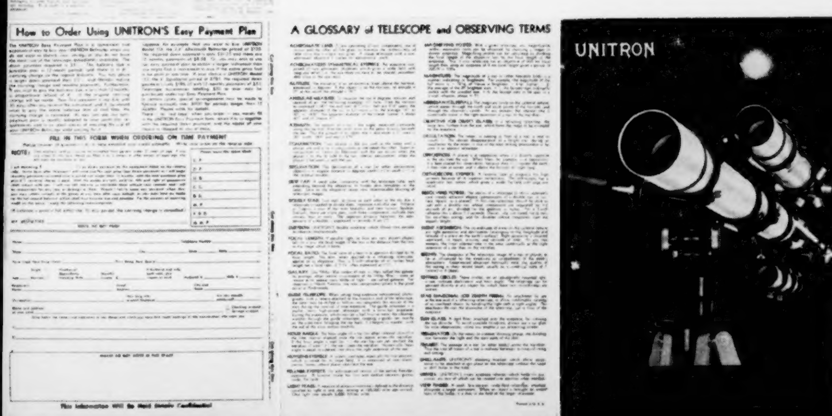

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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

A Closed Tube, Low-Diffraction, Portable Reflector — II

THERE ARE five optical components to my closed tube reflector described in the June issue. These are the primary mirror with a paraboloidal figure, a small diagonal flat, an ellipsoidal secondary mirror mounted at the side of the tube, and two plane-parallel windows. In addition, there are eyepieces or camera accessories. I shall now describe the fabrication of the five principal components and alignment of the system.

Primary Mirror. An 8-inch blank of pyrex was edge-ground in a lathe with a rigid copper bar, using 120 and FF carborundum to get an accurately circular disk that finished 7.834" in diameter. The back surface was ground approximately flat and accurately squared with the edge. After chamfering the edges, I ground the front surface to the proper radius of curvature; then the optical and physical axes were made coincident within 0.0002", checking with a dial-gauge jig during fine grinding. This pretreatment was essential to future stability of alignment. The clear aperture is 7.60" and the focal length 47.98".

All grinding, polishing, and figuring were done on a Draper-type machine,[4] mirror face up, using a 5" cast-iron tool. For fine grinding, $\frac{3}{4}$" squares of $\frac{1}{8}$" plate glass were spindle-ground to fit the tool, attached with paraffin and used with 600 carborundum and UO-4 garnet fines. Preliminary polishing was done with Barnesite on pitch; the final polish and figure were obtained with rouge on pitch.

The figure of the mirror was tested at the focus using a perforated optical flat with a pinhole source in the arrangement of Fig. 6. The beam splitter is a semireflecting pellicle mirror. The light from the source diverges to the mirror, is reflected to the optical flat, thence back to the mirror, which focuses it at the knife-edge. This is a null method, whereby the mirror figure is correct when the surface illumination remains perfectly uniform as the knife-edge cuts the beam.

It is possible to set up this same kind of test with a flat that is not perforated. Then a diagonal of sufficient size is placed on the optical axis just in front of the flat to direct the rays to the primary mirror, while the beam splitter is made smaller and moved closer to the diaphragm, outside of the parallel rays from the mirror to the flat.

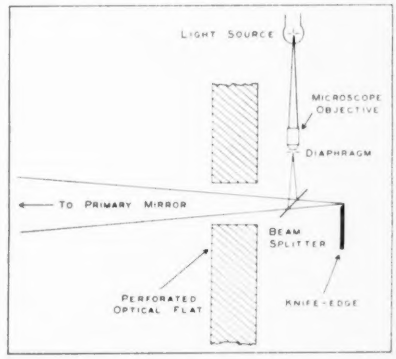

Fig. 6. The setup for null-testing the primary mirror with collimated light.

After having been aluminized, the mirror was given the Platzeck-Gaviola test,[5] using a dial gauge graduated in microns and calibrated against a screw accurate to better than a micron. The curve of surface irregularities is shown in Fig. 7, where the zero line represents 96% paraboloidal correction; this value was chosen as the best compromise between size and brightness of the Airy disk. Except at the edge areas, a common region of difficulty, the figure is well within 1/10 wave length of light.

The mirror was mounted on three polyethylene blocks, each $\frac{1}{4}$" thick and $\frac{3}{8}$" by 1", under the 0.7 zone, and within a Masonite ring turned to an inside diameter of 7.837". A retaining ring of Masonite with projections 120 degrees apart and clearing the edge of the mirror by 0.001" completes the cell. No deformation of the mirror surface due to constraint or thermal effects has been found.

Secondary Mirror. A $4\frac{1}{2}$-inch pyrex blank was edged, ground, and centered in the same manner as the primary mirror blank. The finished diameter is 4.240". Grinding was done face down on

[4] *Amateur Telescope Making—Book One*, page 165.

[5] *Journal*, Optical Society of America, Vol. 29, pages 484-500, 1929; *Amateur Telescope Making—Book Three*, pages 429-456.

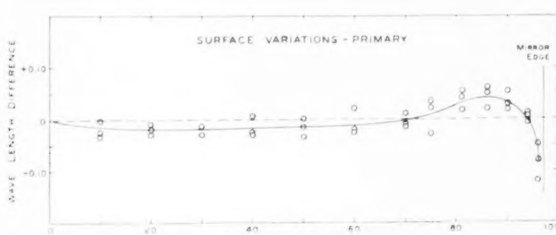

Fig. 7. Here zonal readings of the departures from 96% paraboloidal correction are plotted. The curve has been drawn by inspection to show the approximate character of the mirror's figure.

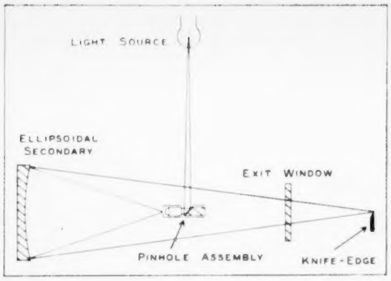

Fig. 8. This arrangement was used for null-testing the secondary mirror.

a 4.5" cast-iron tool on a spindle at 240 revolutions per minute, using 120 carborundum and UO-12 and UO-4 garnet fines. When roughing out was complete, the mirror was spun face up and glass caster cups were ground to curve on the mirror with 150 carborundum; these cups were to be used later as polishers, two of them being 2¼" in diameter and two 3".

The polishing went well on the spindle at 120 revolutions per minute, using Barnesite and then rouge. The curve obtained was spherical with a turned edge ¼" wide. The mean radius of curvature was 8.87".

While the secondary was face up on the Draper machine, figuring was done with the caster cup tools cushioned with 3/32" resin-bonded sheet cork and faced with pitch squares. An epoxy-resin cement[6] was used between cork and glass, and the pitch was secured to the cork with a thin coating of soft pitch.

Testing of the ellipsoidal figure of the secondary was also done by a null method, illustrated in Fig. 8. The light source is a 2-watt zirconium arc bulb. The pinhole assembly, placed at the minor conjugate focus of the secondary, contains a 0.002" pinhole; behind this is an achromatic microscope objective (4-mm. focus, numerical aperture 0.65) corrected for uncovered objects. To make the obscuration as small as possible, this objective was remounted as a cylinder 0.58" in diameter, and the light from the arc source is directed to it by a small diagonal as shown in the diagram.

To obtain the best spherical correction in white light, the arc source (0.0045" in diameter) was placed 11½" from the rear lens of the microscope objective. The image of the light source formed in the pinhole by the objective has a diameter of only 2 microns (0.00008").

The pinhole assembly was supported during the test by a 4-arm spider. The exit window is included in the optical train, so any error introduced by it in the finished telescope could be compensated for by the figuring of the secondary mirror. The knife-edge is located at the major conjugate focus of the ellipse. The conjugate foci are 6.2" and 15.6" from the mirror surface, giving an amplification factor of 2.5.

Although the curve is deep, with a volume of glass to be removed in figuring approximately equal to that of an f/3 paraboloid of like diameter, all figuring was done by polishing. Barnesite was used on a 3" star lap to bring the surface to within about a wave length of the true curve; this took four hours with a 2" elliptical stroke ¼" off center. The stroke speed was 20 feet per minute and the loading 0.6 pound per square inch.

Final figuring was done with rouge, using both sizes of laps, occasionally pressed locally on waxed-paper patterns for zone control. Twenty hours of 3- to 15-minute periods were needed to bring the portion of the ellipsoid used in forming the axial image to 1/10 of a wave. As shown in Fig. 9, when figuring was stopped, some portions of the surface serving the edge of the field still have ¼-wave errors. The data of Fig. 9 were

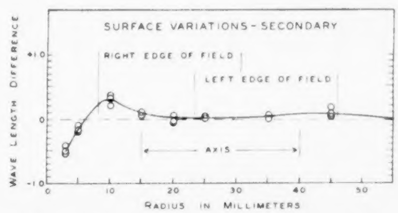

Fig. 9. Figure errors of the secondary.

[6]Bonding Agent R-313, obtainable from Carl H. Biggs Co., Los Angeles 64, Calif.

derived from measurements made at the center of curvature (*ATMA*, page 134) after the surface was aluminized. The secondary is being used off-axis, and these data indicate that it is quite satisfactory for axial imagery, since only the region between the vertical lines labeled "axis" is involved.

Plane-Parallel Windows. Crystallex-brand plate glass was examined in sodium light between crossed polaroid filters and quarter-wave retardation plates for detection of strain patterns. Pieces of the glass were selected that showed no strain. For the exit window, a 4" circle was ground with 600 carborundum from glass ¼" thick until the thickness was uniform within 0.001". It was then fine-ground with 1200 emery and polished on the spindle with Barnesite, working both sides alternately. The final slow polishing was done with rouge on the Draper machine to one-fringe deviation (½ wave). From this circle, a disk 2½" in diameter was biscuit-cut for actual use; it proved to be plane to ¼ wave on each face and parallel to 0.0005" (40 seconds of arc).

For the entrance plate (Fig. 10), a 10.2" circle was cut from glass 5/16" thick. It was decided to make a window of maximum precision in this case for occasional use as a pinhole support for a 10-inch paraboloidal collimator, to replace a window made 20 years ago and known to introduce detectable errors. For use in the telescope only, however, lower precision would have sufficed.

By working on alternate sides with the Draper machine, using 600 carborundum, and testing with a dial-gauge jig graduated in microns, parallelism of one micron was easily obtained with reasonable flatness. The disk was supported on a cast-iron flat and cushioned on thin dimpled-rubber carpet backing for polishing and figuring. For the latter process, the rubber was lubricated with glycerin. A 7" channeled glass tool was used à la Ferson (*ATMA*, page 95) for fine grinding, and a 6½" by 1" pitch-faced glass lap for polishing and figuring. Rouge was the polishing agent. The faces were worked alternately.

Testing for planeness was by interference against an accurate flat supported vertically in such a manner that errors were presumably less than 1/20 wave (*ATMA*, page 125). The final results were checked by floating the plane parallel on mercury covered with black filter paper and observing the fringes between the upper surface of the glass and the surface of a layer of clean water covering the plate.

For testing parallelism of the faces to 10 seconds of arc, a pinhole was observed at grazing incidence,[7] and the double images were made to coincide by selective

Fig. 10. A Crystallex entrance window supports the very small diagonal.

polishing. Below this range, Haidinger's fringes (*ATMA*, page 127) were employed. It was found impossible to duplicate flatness tests with a precision better than 1/10 wave, and Haidinger's fringes varied as much as half a fringe during travel across the plate in certain azimuths, although no fringe movement could be detected over more than three fourths of the paths traversed. Since no birefringence was detected in strain testing, the reason seems to be a slight inhomogeneity in the composition of the Crystallex.

The surfaces of the entrance window are probably flat to 1/10 wave and physical parallelism is one second of arc. The lack of uniformity of the glass causes a path difference of much less than 1/10 wave, as shown by testing a paraboloid at focus with and without interposing the plate. In general, a telescope entrance plate should be satisfactory for critical work if the surfaces are smooth and flat to half a wave, if the faces are parallel to five seconds, and if the glass is free from strain and striae.

The plane parallels are mounted between 1/16" sheet-cork gaskets, and their edges are separated from the enclosing aluminum rings by cork strips. No anti-reflection coating has been given these windows. I prefer to ignore the faint spurious images noted when a very bright star, such as Sirius, is observed to taking the risks involved in heating the coating after its deposition.

Note on Lap Design. To avoid zones as much as possible, draw on a disk of wood the facets and channels proposed for a lap, blackening the facet positions and leaving the channels light. Spin the disk in an independent lathe chuck and shift the disk until the most uniform gray results. Then mark the center with

[7] *Review of Scientific Instruments* (New Series), Vol. 7, pages 216-217, 1936.

a punch held in the tailstock. Facets laid out in this manner are least prone to make zones.

Diagonal. A war-surplus prism, selected for freedom from strain and for flatness of one face, was ground to a cylinder 1" long and 0.58" in diameter. The axis of the cylinder was set 50 degrees to the chosen face, which was protected by a paraffin-cemented cover glass during grinding. An annulus was biscuit-ground in the back of the prism and a Micarta rod was turned to fit the annulus. After the prism face was aluminized, the prism was adjusted for position as described below and held in position with lacquer.

Alignment. Good alignment is essential to good performance in a Johnsonian telescope, and the requirements are much stricter than for a Newtonian. Each worker may have his own preference for alignment procedure. The following is mine.

A collimator is set up using another paraboloid of any size with a 2-watt zirconium arc at the focus. The telescope tube without the dewcap or entrance window is supported in cradles in front of the collimator.

A circle of the diameter of the tube flanges is drawn on each of two sheets of hard but translucent bond paper. Concentric ink circles $\frac{1}{8}$" larger than the collimator mirror are also drawn. On one sheet is added a target of circles $\frac{1}{2}$" to $1\frac{1}{2}$" in diameter in steps of $\frac{1}{4}$". This target sheet is cut into a wheel with four spokes $\frac{3}{8}$" wide to support the target. The inside of the wheel is $\frac{1}{4}$" larger than the collimator mirror. Both disks are cut out on the large circle and taped to the tube flanges, the target disk facing the collimator.

The tube is made concentric with the collimator axis by observing the illumination of the paper disks by the collimator beam (in a darkened room) and moving the tube appropriately. Once aligned with each other in this manner, neither tube nor collimator should be moved. Rigid clamps are recommended.

The unspoked mask is removed and the primary mirror in its cell is attached

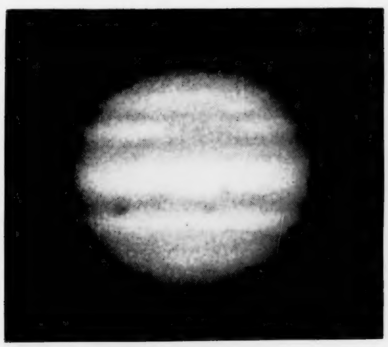

Fig. 11. Jupiter, photographed with the Selby telescope at 3:51 Universal time, on March 19, 1956.

to the telescope tube; the mirror reflects a bright cone of light on the target. This bright spot is centered by shimming the mirror support at the polyethylene pads and the lug ring.

The secondary mirror is mounted in a centered lathe chuck having padded jaws and is adjusted so that no wobble occurs during rotation when an object is viewed by reflection from the mirror. A ⅜" circle is then drawn on the reflecting surface with ink by a pointed brush or matchstick held in the tool post. The mirror is then set in its mount, with the masks removed.

A translucent paper mask with a ⅛" central hole is centered in the eyepiece mount at the place chosen for the secondary focus, and the secondary is shimmed where needed to bring the reflection of the hole to the center of the ⅜" circle when the worker observes the mirror through the mask. The mask and secondary are illuminated and the eye is held 6" to 12" from the mask.

The diagonal is placed in position after the mirrors have been aligned, with the collimator image being brought to the center of the hole in the small mask by cocking and rotating the diagonal on its support. This should complete alignment of the parts, and removal of the mask at the eyepiece end will allow the reflection of the open end of the tube to be seen in the secondary in its correct place. The diagonal will not interfere with but will be close to the cone serving the edge of the field. Also, the point of sharpest focus will be found where it belongs—centered and at its proper distance from the surface of the secondary. Collimator, arc, and diagonal will be concentric.

Should all of these conditions not be found, changes and realignment are in order. First, observe the diagonal from the edge of the field nearest the open end of the tube and move the diagonal lengthwise so that its edge barely touches the circular reflection of the tube end as seen in the secondary. Then, replace the eyepiece tube mask and center the collimator image again.

If the focus is too far from the secondary, the primary or secondary should be moved along its own axis away from the diagonal. If the tube reflection seen in the secondary is to one side of the tube axis, the axes of the secondary and the primary do not intersect; the secondary must be shifted *around* the tube to correct the trouble. Shifting of either mirror will make necessary repeating of the entire alignment procedure.

The troubles covered in the preceding two paragraphs will not occur if an accurate drawing of the system is made to match the mirrors after they are finished, and is followed closely in building the tube.

If the collimator mirror is at least as large as the primary, and if it has an excellent figure, the aligned telescope can be checked for definition by substituting a fine pinhole illuminator for the zirconium arc using the arrangement of Fig. 8. If the pinhole is supported on a plane-parallel plate, results similar to those found in observing a star will be possible without the effects of our turbulent atmosphere.

H. H. SELBY
815 Britain St.
San Diego 14, Calif.

NOTES ON BASIC OPTICS

The next installment of this series will appear in the August issue.—ED.

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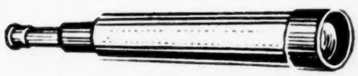

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81 mm "	3¼" "	**6.50**
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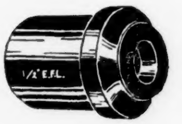

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54 mm (2⅛")	1016 mm (40")	**12.50**	110 mm (4⅜")*	1069 mm (42 1/16")	**60.00**
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A. JAEGERS

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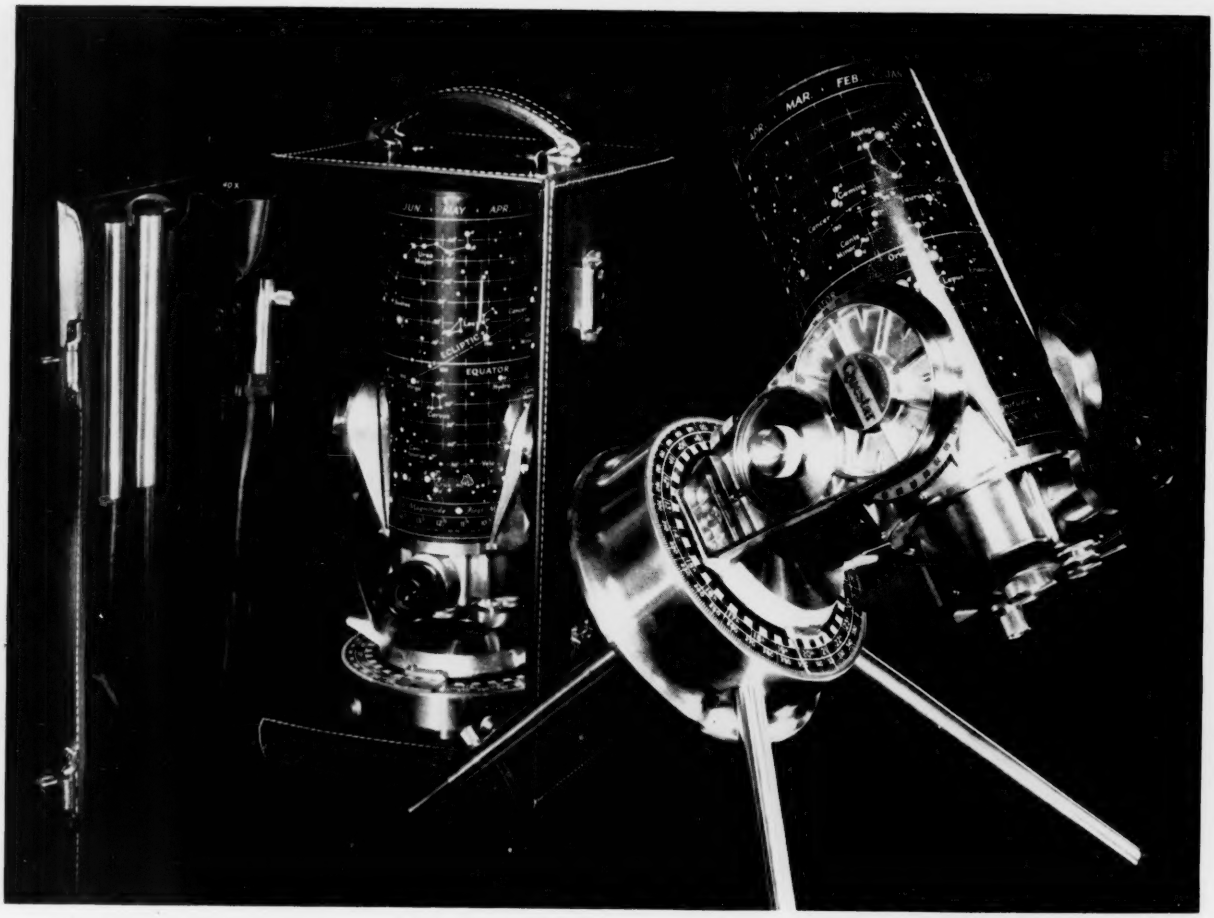

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The photograph cannot show the deep blue jewel-like color of the engraved enamel-filled perpetual star chart, but it does indicate Questar's honest engine-turned aluminum and stainless steel.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

JUST BELOW and to the west of Scutum, and near the Sagittarius small starcloud, lies a region commonly disregarded by amateurs and handbooks alike. Yet it contains several Messier objects, and a profusion of rich Milky Way fields. Here lie M16, M17, M18, M24, and NGC 6561, but the reader will not find them described in Smyth or in Webb, and Barnes plots only M17 and M24. Still they are worth the trouble of digging out.

At the 1950 co-ordinates 18^h $16^m.0$, $-13°$ 48′, the 7th-magnitude galactic cluster M16 (NGC 6611) contains over 100 stars and a few wisps of intermixed nebulosity. M17 (NGC 6618), at 18^h $17^m.9$, $-16°$ 12′, is a bright diffuse nebula that spreads over a larger area than the moon. It is variously known as the Omega and the Horseshoe nebula. Overpowering on photographs, it retains much of its awe even in small telescopes, especially during prolonged study. I have found a Barlow lens useful in observing its details.

Less than a degree south there is M18 (NGC 6613), at 18^h $17^m.0$, $-17°$ 09′, a galactic cluster only 7′ in diameter, but favorably located against the somber background of dark nebulosity. Another cluster, M21 (NGC 6603), 18^h $15^m.5$, $-18°$ 26′, is 1′ in diameter, almost lost against the rich Sagittarius small starcloud. It is often difficult to locate on photographs, but telescopes of medium focal ratio will show it readily.

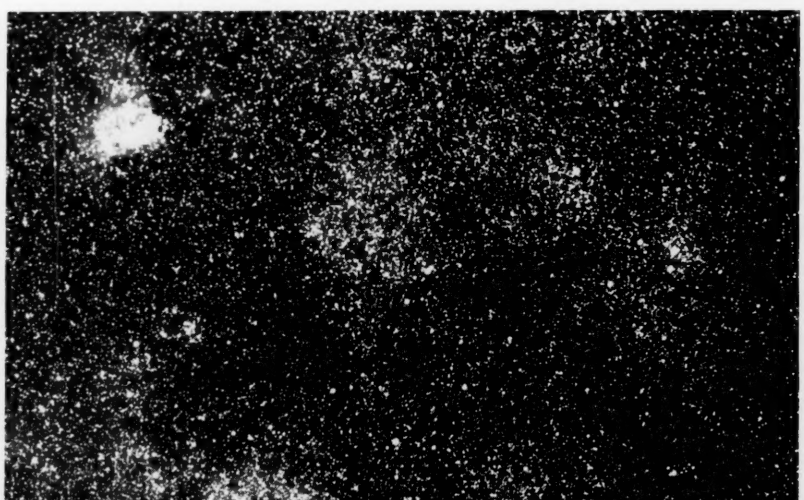
Just to the west lies B92, one of Barnard's dark nebulae. It is an unusual jet-black patch, 15′ by 9′ in size, with a solitary 12th-magnitude star in its center. When seeing is excellent, rich-field telescopes will readily show the existence of this object.

Seldom included in lists of galactic clusters, NGC 6561 (labelled 54^8 in Norton's *Atlas*) is still worth inspection, a loose scattering of stars most impressive with a 10-inch aperture or more. It lies at 18^h $07^m.6$, $-16°$ 49′. Comparing this object and the others, on the accompanying photograph from Barnard's *Atlas*, with their visual aspects in the telescope will show that both methods of observing have their advantages.

WALTER SCOTT HOUSTON
Rt. 3, Manhattan, Kans.

JULY METEORS

One of the more active meteor showers, the Delta Aquarids, is favorably observable at the end of July. Maximum activity is due on the 30th, but smaller num-



All of the deep-sky wonders described above (except M16) can be found on this reproduction of part of Plate 31 of Barnard's Milky Way atlas (1927). North is above, and the scale is 0.7 degree per inch. The Omega nebula is the prominent bright cloud in the upper left corner, and M18 lies $1\frac{1}{4}$ inch to its lower right. The conspicuous black marking $\frac{3}{4}$ inch above the middle of the lower edge of the field is B92, and M24 is an inch to its left. NGC 6561 lies $1\frac{1}{2}$ inches below the top and $\frac{3}{4}$ inch from the right edge.

bers of these medium-speed meteors can be seen a week before and after. The predicted peak rate is 20 per hour after midnight, but may be lower since the last-quarter moon will be rising, in the Pisces-Aries region. The radiant point of the Delta Aquarids is $22^h\ 40^m$, $-15°$.

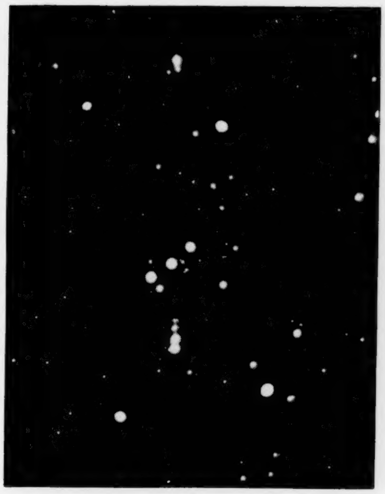
E. O.

STAR PHOTOGRAPHY WITH A SIMPLE LENS

An ordinary plano-convex condenser lens is perhaps the simplest means of obtaining a usable photograph of a moderately large area of the sky. The accompanying picture of Orion demonstrates the capabilities and weaknesses of this method.

It was obtained with an f/1.7 condenser lens of about seven inches focal length, stopped down to f/6. To minimize astigmatism, the curved surface of the lens was turned toward the film. Guiding was by hand, with a modified 7 x 50 monocular fitted with crosshairs of No. 36 wire. The guide star was brought back to the intersection of the crosshairs about once every 10 seconds.

Several types of lens aberrations are apparent in the photograph. A star image formed by the lens consists of a bright core surrounded by a larger and fainter disk. For the brightest stars the entire disk registers, but faint images consist of core alone; stars of intermediate brightness show both features.



Mr. Fisher used a simple condensing lens for this 23-minute exposure of Orion on Super-XX film.

This picture should be compared with Hans Pfleumer's photograph of Orion on page 234 of the March issue, made with a camera of comparable speed and focal length, and a not-too-different exposure time. The important difference is Mr. Pfleumer's use of a corrected lens.

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TRANSIT OF EUROPA ACROSS GANYMEDE?

On the evening of May 3, 1956, at 4:00 UT, I made a routine observation of the configuration of Jupiter's satellites with my 3½-inch Skyscope reflector at 120x, and noticed that **II** (Europa), **III** (Ganymede), and the center of Jupiter's disk lay almost on the same line.

By 4:40 it became certain that **III**, the brighter and larger, would soon overtake **II**, possibly passing directly behind it. The configuration diagram in the May issue showed that **II** was very near eastern elongation, and hence almost stationary; **III**, moving in a larger orbit, would still have an appreciable eastward motion. Therefore I decided to stay at the telescope and watch.

At 5:15 the satellites were barely separated, with **III** still west of **II**. Seeing was good, about 6 on a scale of 0 to 10. The two images seemed to join at 5:18, and the brightest part of the combined image was to the west. By 5:30 the combined image was round, and about as bright as Ganymede alone. At 5:47 the image began to elongate, but with its brighter portion now to the east. Thirteen minutes later I was certain that, if a transit had occurred, it was now over. At 6:12 the two satellites were very obviously separated, even though the seeing was poorer because Jupiter was then low in the west.

With my small telescope, I could not be certain that an actual transit of **II** across the face of **III** took place. Perhaps other observers with larger instruments and better seeing were able to settle this question.

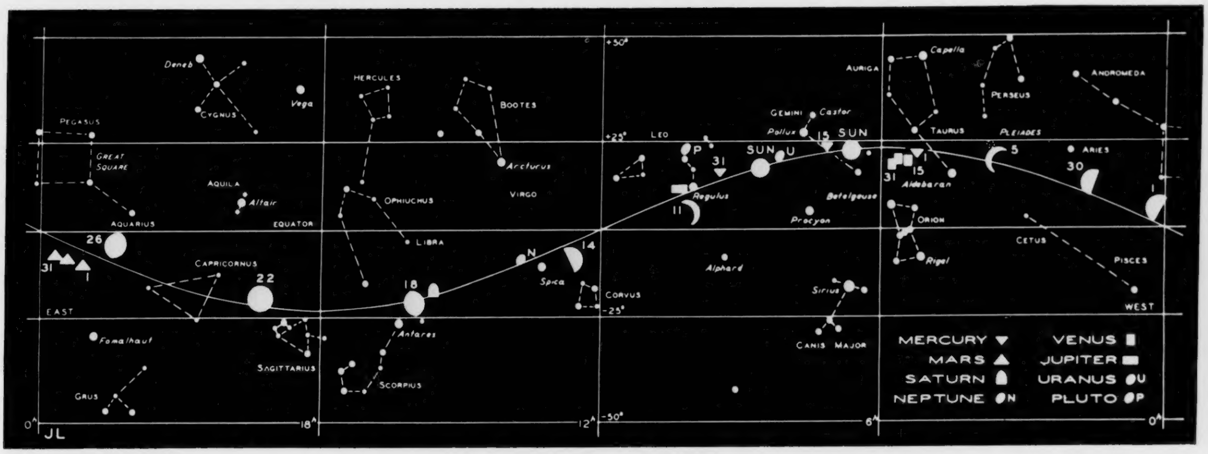
M. FRANCIS
3508 Wilcox
Bellwood, Ill.

AURORAL OBSERVATIONS

As solar activity steadily mounts toward the maximum predicted for next year, displays of the northern lights should become more frequent and more striking. Dr. J. R. Otoupalik, Greeley, Colo., saw a bright aurora for two hours on the evening of April 26th, although the moon was only one day past full. Spreading completely across the northern horizon, the glow had reached as high as Polaris before increasingly bright moonlight ended the spectacle. At Lindstrom, Minn., John Gilcreast reported a strong display the next evening, extending nearly to the southern horizon, despite hazy skies.

On May 23rd, one solar rotation later, members of the Amateur Telescope Makers of Boston observed an aurora with red patches. At 9 p.m. EST the next night, at Weymouth, Mass., Samuel Gardiner saw auroral rays, part of a bright display, extending southward of the zenith.

All the foregoing displays thus seem due to one active region on the sun. A large sunspot group in latitude 20° south was near the central meridian of the sun on May 24th.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury may be viewed in both the morning and evening skies in July, but with difficulty. During the first week the planet rises about one hour before the sun, and is of about −0.5 magnitude. Superior conjunction occurs July 19th, and by the month's end Mercury sets some 45 minutes after the sun, at magnitude −1.0.

Venus becomes visible in the morning sky at the beginning of the month. On the 4th, it rises an hour before the sun, its narrow crescent an interesting telescopic sight: the disk is 54 seconds of arc in diameter, and only five-per-cent illuminated. By the end of July, Venus rises three hours before sunrise, and the area of illumination has increased to 29 per cent. Greatest brilliancy occurs on July 29th, at magnitude −4.2.

Mars rises about $2\frac{1}{2}$ hours after sunset in midmonth. Moving eastward in Aquarius, the brilliant red planet brightens from magnitude −1.0 to −1.8 during July. The Martian disk is 20″ in diameter on the 31st, discernible as such in small telescopes.

Jupiter will be visible only during evening twilight, low in the west. On July 3rd the planet passes 31′ north of the star Regulus, in the last of a series of three conjunctions.

Saturn sets about midnight, local time, at the end of July. The planet ends retrograde (westward) motion on the 31st, when it is about four degrees south of Gamma Librae. In midmonth Saturn shines at magnitude +0.6, and the plane of its ring system appears inclined 23°.7 to our line of sight.

Uranus is not visible in July, as it is in conjunction with the sun on the 25th.

Neptune can be located with binoculars during evening hours only. This 8th-magnitude planet begins eastward motion on July 9th, but its position changes very little during the month. On the 15th, its right ascension is $13^h\ 44^m.9$, declination −8° 59′ (1950). Neptune passes eastern quadrature with the sun on July 20th.

E. O.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

VARIABLE STAR MAXIMA

July 5, R Aquilae, 190108, 6.3; 6, T Ursae Majoris, 123160, 7.9; 18, S Virginis, 132**706**, 7.1; 23, T Normae, 153**654**, 7.4; 29, S Carinae, 100**661**, 5.7; 29, R Draconis, 163266, 7.6; 31, RV Sagittarii, 182**133**, 7.8.

August 2, T Aquarii, 204**105**, 7.9; 4, S Pegasi, 231508, 8.0; 10, R Canum Venaticorum, 134440, 7.7.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude

THE GREEK ALPHABET

The brighter naked-eye stars are often designated by their Greek-letter names, such as α Bootis for Arcturus, particularly on star maps. Readers may find the following list useful for reference.

α	Alpha	ι	Iota	ρ	Rho
β	Beta	κ	Kappa	σ	Sigma
γ	Gamma	λ	Lambda	τ	Tau
δ	Delta	μ	Mu	υ	Upsilon
ε	Epsilon	ν	Nu	φ	Phi
ζ	Zeta	ξ	Xi	χ	Chi
η	Eta	ο	Omicron	ψ	Psi
θ	Theta	π	Pi	ω	Omega

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By removing 3 screws, you can separate scope into 2 pieces, one of which makes an excellent 6-power finder for an astronomical telescope on which reticle can be illuminated for night use. To give you some idea of the intrinsic value you are getting here — as surplus, the lenses alone would cost double the price we are asking for the entire instrument. Bear in mind, too, that the eyepiece by itself can be used for an astronomical telescope.

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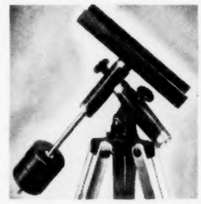

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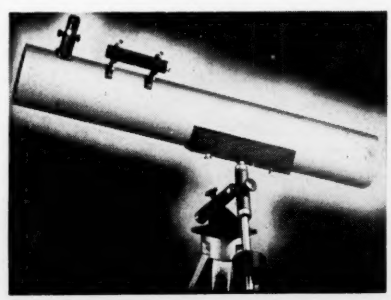

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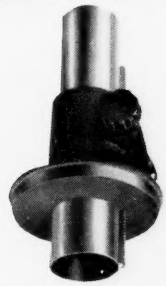

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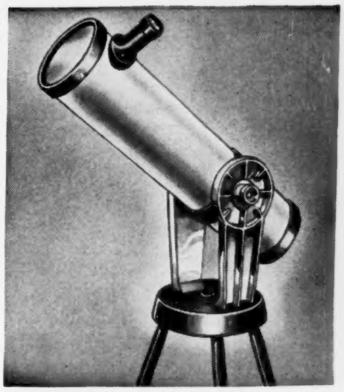

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About 14" high on a 7" x 7" base.

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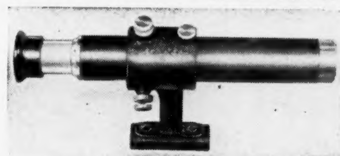

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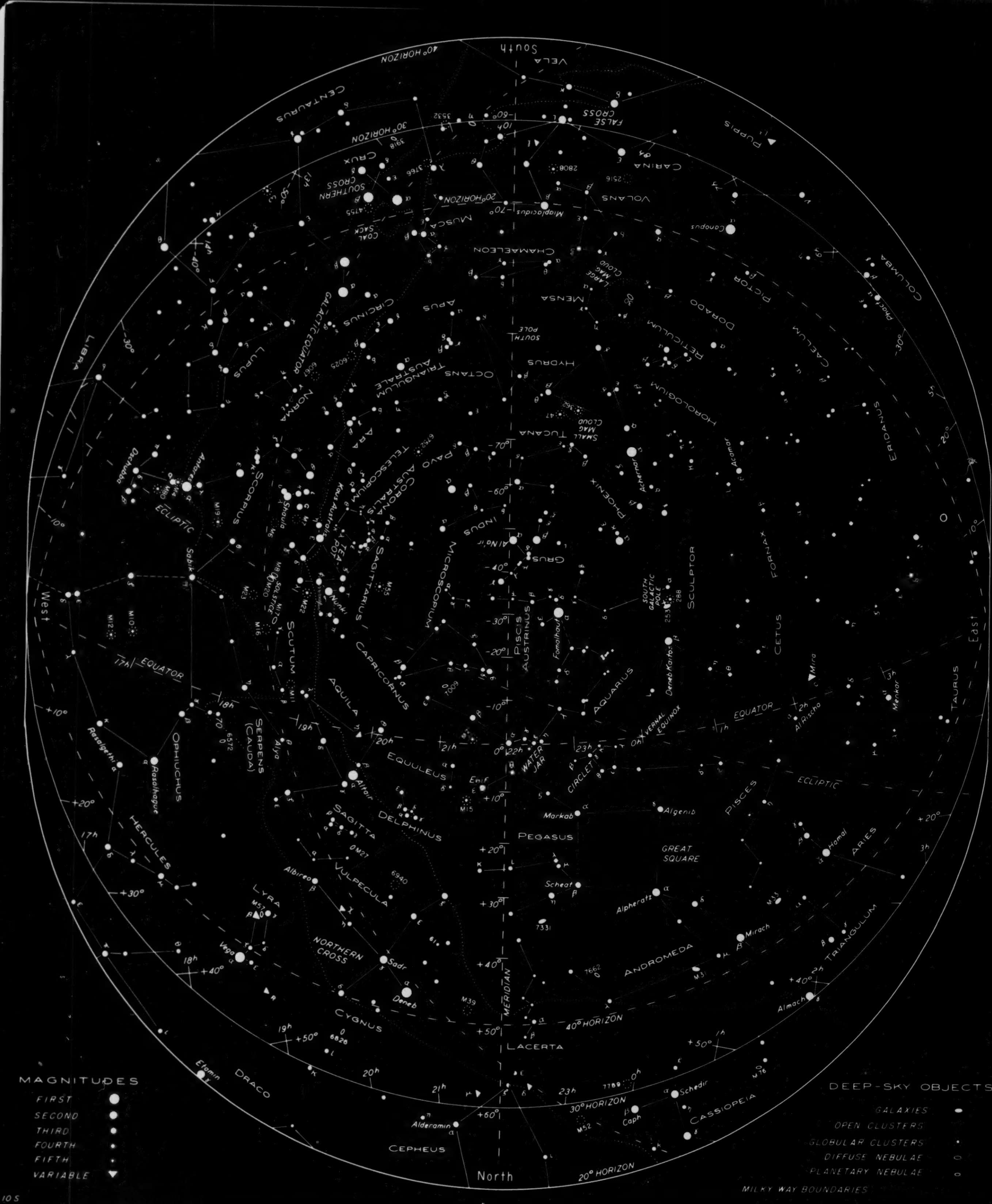
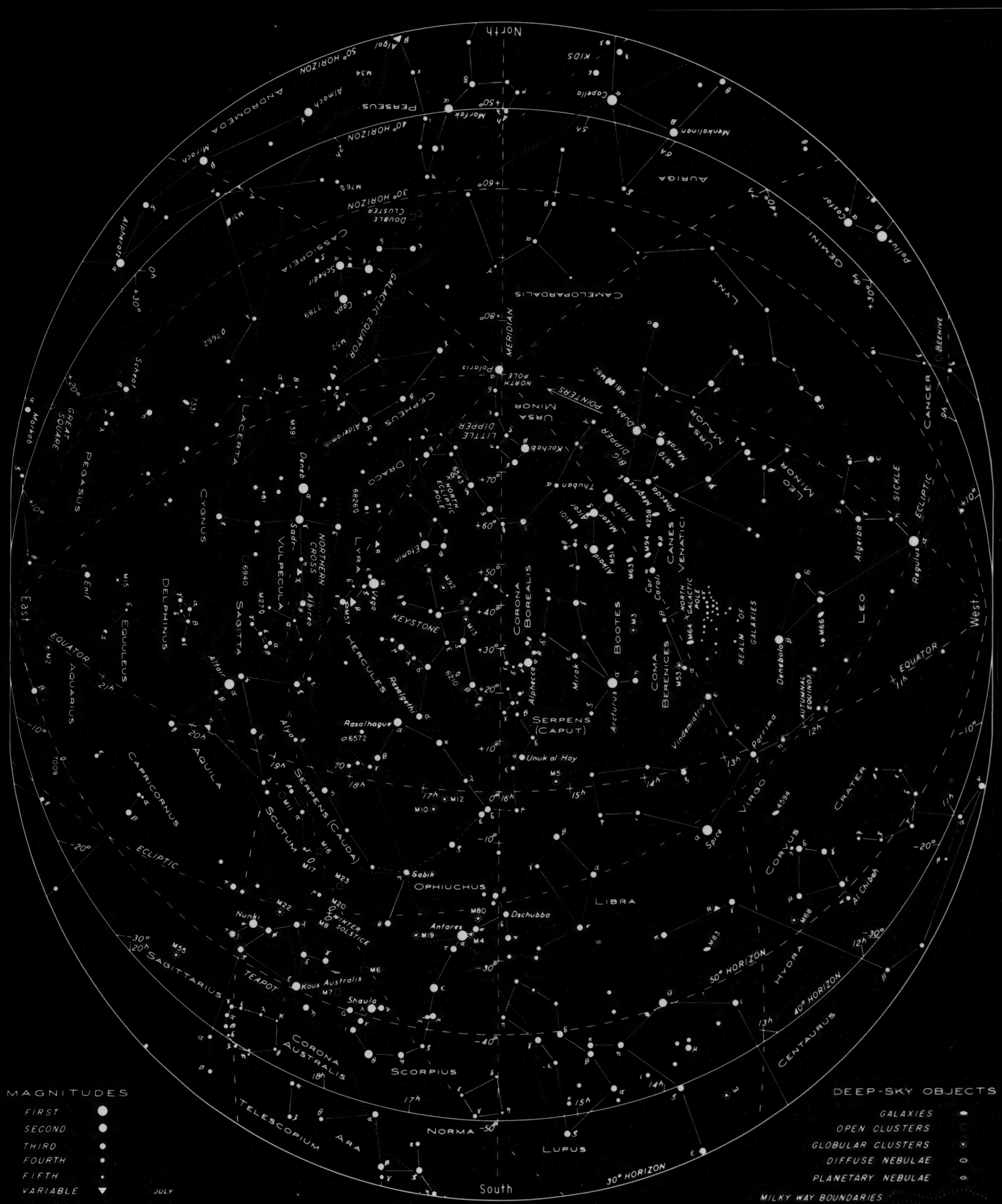


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of October, respectively; also, at 7 p.m. and 6 p.m. on November 7th and 23rd. For other dates, add or subtract ½ hour per week. When facing south, hold "South" at the bottom; turn the chart correspondingly for other directions. On the stereographic projection used in this chart, celestial hour circles and parallels are represented as parts of circles, and an observer's horizon is always a circle.



STARS FOR JULY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. on August 7th. For other dates, add or subtract ½ hour per week.

In the eastern sky, note the great "summer triangle" formed by the 1st-magnitude stars Vega, Deneb, and Altair, a veritable super-constellation. In the lower southern sky, the bright red star Antares attracts attention to a favorite group, the Scorpion.

DOUBLE STAR OBSERVATIONS

Mr. Houston's column on Delta Cygni in the May issue, page 331, interested me particularly, as I had begun a program of double star observing with my 3½-inch reflector. This telescope is equatorially mounted, and I have added hour-angle and declination circles. For double stars I use a 4-mm. microscope objective as a telescope eyepiece, giving a power of 240x. From my observing notes I have selected the following doubles closer than four seconds of arc that I have split. After the name of each pair are given the magnitudes of its components and their separation in seconds of arc.

2 Comae, 6.0-7.5, 3.8; Gamma Ceti, 3.0-6.8, 3.2; Epsilon[1] Lyrae, 4.6-6.3, 3.1; Epsilon Bootis, 3.0-6.3, 2.8; Epsilon[2] Lyrae, 4.9-5.2, 2.3; Mu Librae, 5.4-6.3, 2.1; Delta Cygni, 3.0-6.5, 2.1; Zeta Aquarii, 4.4-4.6, 1.9; Xi Ursae Majoris, 4.4-4.9, 1.8; Zeta Herculis, 3.1-5.6, 1.6; and 52 Orionis, 6.2-6.2, 1.5.

RENE A. WURGEL
634 39th St.
Union City, N. J.

SUNSPOT NUMBERS

April 1, 79, 60; **2,** 49, 69; **3,** 37, 66; **4,** 22, 66; **5,** 31, 50; **6,** 36, 45; **7,** 53, 63; **8,** 84, 86; **9,** 107, 103; **10,** 134, 145; **11,** 140, 144; **12,** 169, 160; **13,** 170, 178; **14,** 147, 164; **15,** 161, 150; **16,** 130, 120; **17,** 188, 130; **18,** 173, 140; **19,** 161, 130; **20,** 139, 140; **21,** 135, 140; **22,** 124, 120; **23,** 86, 115; **24,** 76, 96; **25,** 91, 104; **26,** 82, 88; **27,** 78, 94; **28,** 57, 67; **29,** 57, 32; **30,** 77, 70. Means for April: 102.4 American; 104.5 Zurich.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

Dr. M. Waldmeier, of Zurich Observatory, has predicted smoothed monthly sunspot numbers for the next few months: July, 143; August, 148; September, 153; and October, 157.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Pallas, 2, 9.1. July 16, 21:43.9 +14-12; 26, 21:37.9 +13-34. August 5, 21:30.8 +12-32; 15, 21:23.2 +11-08; 25, 21:15.6 +9-24. September 4, 21:08.9 +7-26.

Dembowska, 349, 9.4. July 26, 22:16.4 −23-43. August 5, 22:09.5 −24-29; 15, 22:01.2 −25-11; 25, 21:52.3 −25-40. September 4, 21:43.9 −25-53; 14, 21:36.9 −25-50.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

July 2, 23:40; 5, 20:29; 8, 17:17; 11, 14:06; 14, 10:55; 17, 7:43; 20, 4:32; 23, 1:20; 25, 22:09; 28, 18:58; 31, 15:46. August 3, 12:34; 6, 9:23; 9, 6:12.

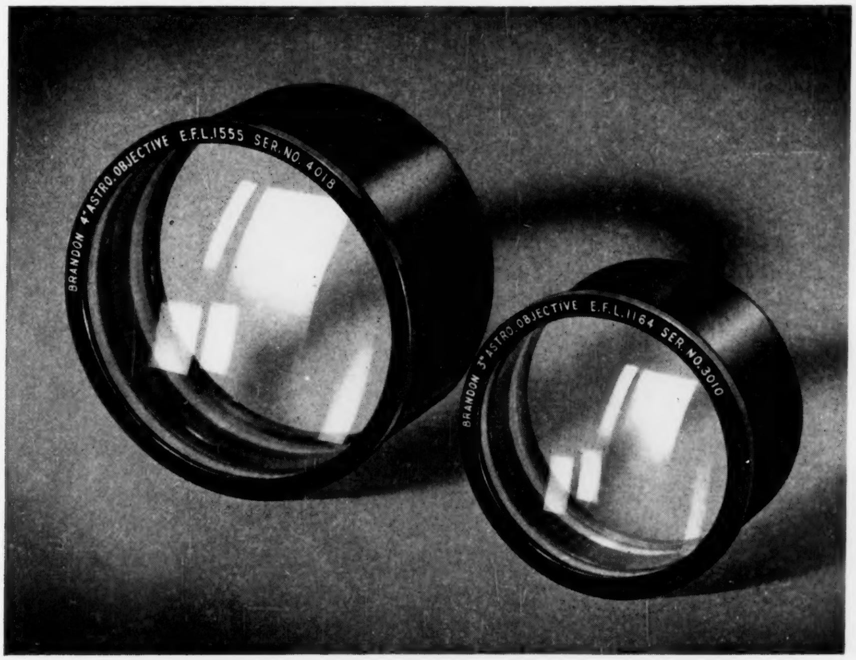
These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

MOON PHASES AND DISTANCE

Last quarter	July 1, 8:40
New moon	July 8, 4:37
First quarter	July 14, 20:46
Full moon	July 22, 21:29
Last quarter	July 30, 19:31
New moon	August 6, 11:25

	July	Distance	Diameter
Perigee	8, 11^h	222,100 mi.	33′ 26″
Apogee	22, 11^h	252,500 mi.	29′ 25″
	August		
Perigee	5, 21^h	222,400 mi.	33′ 23″

Brandon Astronomical Objectives



Each 4-inch and 3-inch Brandon objective is shipped already mounted in a cell, ready to attach to your own tube of aluminum, brass, steel, or plastic.

NOW ANY AMATEUR CAN MAKE HIS OWN REFRACTOR!

As every exacting telescope user knows, the heart of a telescope is its objective lens or primary mirror. It is difficult to make the four surfaces of an achromatic two-element lens, and few amateurs tackle the task. But the mounting of a mirror and the maintenance of a reflecting telescope are often costly and time-consuming, while a refractor can be constructed easily and inexpensively with one of our astronomical objectives. The finished instrument requires little attention over the years and is always worth its original cost.

Therefore, if you want to get the most telescope for your time and money, buy one of our first-quality objectives and mount it yourself simply by attaching the cell to a tube of the proper diameter and length. The other end of the tube should carry a smaller sliding tube which in turn has an eyepiece holder. Focusing may be done by sliding one tube in the other, by rack and pinion, or by a spiral-focusing mechanism.

You have no diagonal support problem, no diagonal or prism to shake loose, no complicated aligning, no diffraction patterns of diagonal and support. Even the five-foot tube assembly of a 4-inch refractor is light and easy to mount as an altazimuth or equatorial instrument (see *Amateur Telescope Making—Book Two*, pages 192-211). It can be put on a tripod that is easily portable or on a permanent pier. Refractors are noted for the ease with which they can be set up and taken down; they pack easily into boxes for shipment and travel. The refractor lens provides a large field of excellent definition suitable for all kinds of eyepieces and for direct or projection photography. Either of our objectives, combined with any of our seven eyepieces, gives a wide range of powers:

Size of eyepiece:	4-mm.	6-mm.	8-mm.	12-mm.	16-mm.	24-mm.
3-inch f/15 lens:	290x	195x	145x	95x	75x	50x
4-inch f/15 lens:	390x	260x	195x	130x	95x	65x

When atmospheric conditions permit, you can take advantage of the well-known resolving power of the refractor. You have the perfect instrument for observing details on the planets, such as Mars when nearest to us this summer. Each Brandon lens is rigidly tested for its resolution of double stars before being sold. Brandon objectives enjoy an enviable reputation among professional and amateur astronomers for their fine performance. Check these features:

1. Superior optical design utilizing a larger air separation. Color corrected on C and F and hand corrected to reduce residuals to a minimum. Completely free of coma.

2. Glass-air surfaces magnesium-fluoride coated, increasing light transmission approximately 10 per cent.

3. Quality optical glass precision annealed and held to one ring test-plate match.

4. Cell made to precision tolerances and suitably coated to prevent stray light reflections. Each cell engraved with effective focal length and serial number.

These objectives are supplied with cells and rigidly tested on double stars for resolving power before being sold:

3" Clear Aperture	**45.8" Focal Length**	**$ 62.00**
4" Clear Aperture	**61.2" Focal Length**	**$138.00**

Your order, accompanied by check or money order, will be filled immediately and sent air-mail insured.
Send self-addressed 6¢ (air mail) stamped envelope for other dimensions. Satisfaction guaranteed, or your money will be refunded.

Brandon Instruments

GUAYNABO, PUERTO RICO